EL-MOASSER

By A Group Of Supervisors

PHYSICS

MAIN BOOK

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FIRST TERM

GPS

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CONTENTS

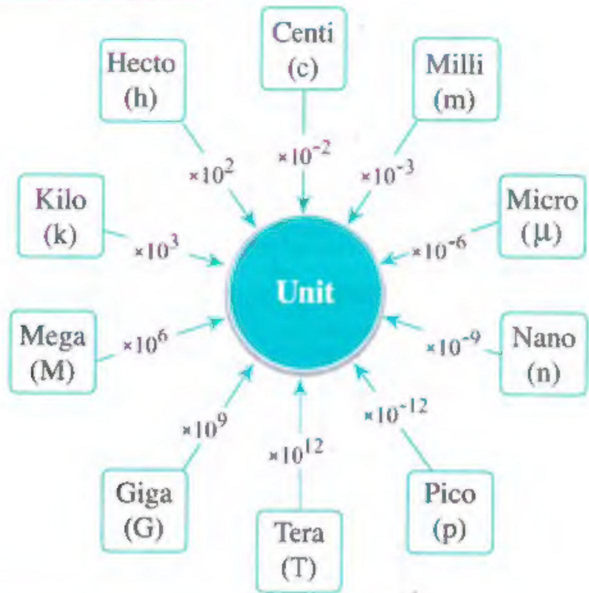
Table of physical quantities, their symbols, units of measurement and dimensional formulae

Physical quantity	Symbol	Unit of measurement in the international system of units		Dimensional formula
Length	ℓ	meter	m	L
Distance	s	meter	m	L
Displacement	d	meter	m	L
Radius	r	meter	m	L
Height	h	meter	m	L
Circumference	c	meter	m	L
Mass	m	kilogram	kg	M
Time	t	second	s	T
Area	A	$meter^2$	m^2	L^2
Volume	V	$meter^3$	m^3	L^3
Electric current intensity	I	ampere	A	-
Absolute temperature	T	kelvin	K	-
Amount of substance	n	mole	mol	-
Luminous intensity	I_v	candela	cd	-
Plane angle	-	radian	radian	-

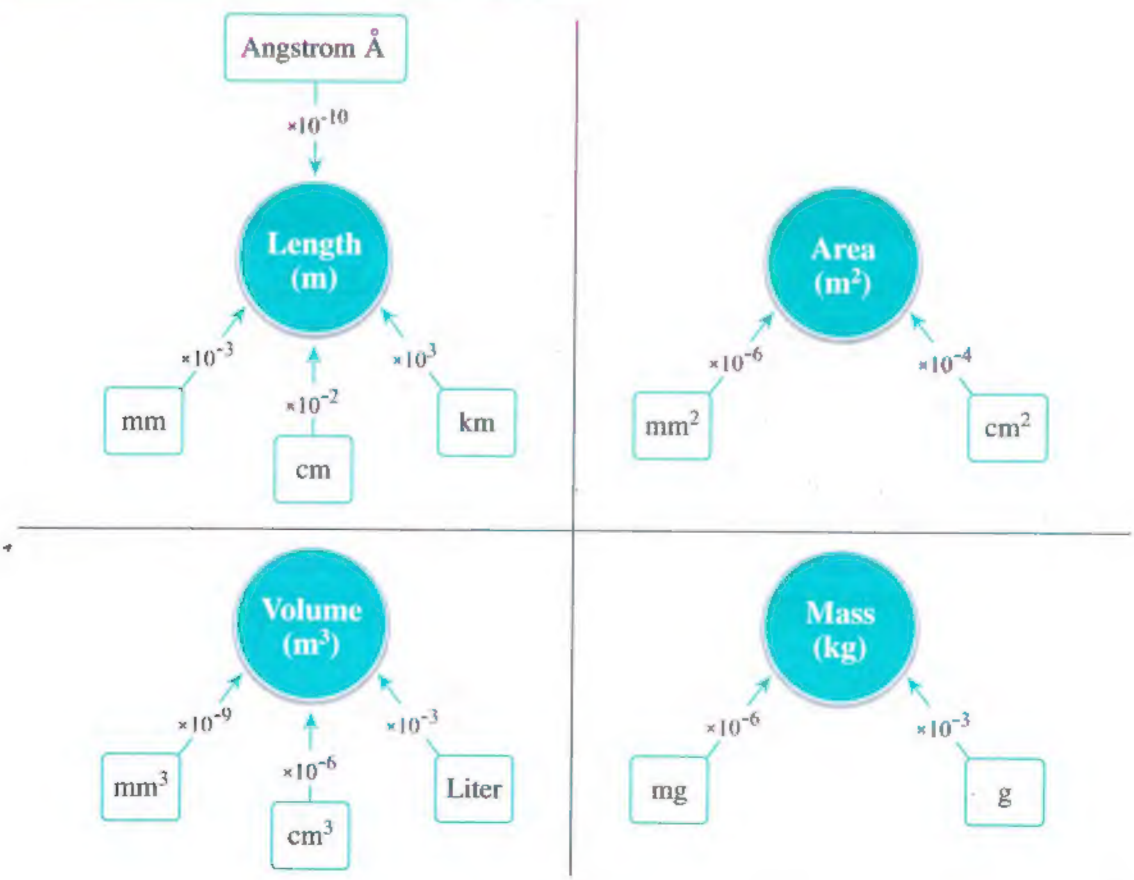
Physical quantity	Symbol	Unit of measurement in the international system of units		Dimensional formula
Solid angle	-	steradian	steradian	-
Density	ρ	kilogram/meter^3	kg/m^3	ML^{-3}
Velocity, Instantaneous velocity	v	meter/second	m/s	LT^{-1}
Average velocity	$\bar{v}$	meter/second	m/s	LT^{-1}
Acceleration	a	meter/second^2	m/s^2	LT^{-2}
Acceleration due to gravity	g	meter/second^2	m/s^2	LT^{-2}
Force	F	kg.meter/s^2 **Or** Newton	kg.m/s^2 **Or** N	MLT^{-2}
Momentum	P_L	kilogram.meter/ second	kg.m/s	MLT^{-1}
Universal gravitational constant	G	Newton.meter^2/ kilogram^2 **Or** meter^3/ kilogram. second^2	N.m^2/kg^2 **Or** m^3/kg.s^2	$M^{-1}L^3T^{-2}$
Work	W	kilogram.meter^2/ second^2 **Or** Newton.meter **Or** Joule	kg.m^2/s^2 **Or** N.m **Or** J	ML^2T^{-2}
Energy	E			

Integration with Mathematics

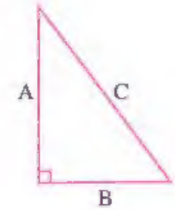
1 Prefixes for powers of 10



2 Conversions of some specific units



3 Pythagorean theorem



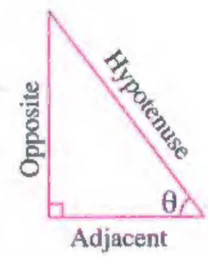
In the right triangle the square of the hypotenuse is equal to the sum of squares of the other two sides

i.e. $C^2 = A^2 + B^2$

$\therefore C = \sqrt{A^2 + B^2}$

Where: C is the hypotenuse and A, B are the other two sides.

4 Trigonometrical relations



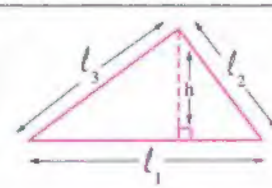
In the right triangle, we can determine the trigonometrical ratios for the angle θ from the following relations:

$\sin\theta = \dfrac{\text{Opposite}}{\text{Hypotenuse}}$, $\cos\theta = \dfrac{\text{Adjacent}}{\text{Hypotenuse}}$, $\tan\theta = \dfrac{\text{Opposite}}{\text{Adjacent}}$

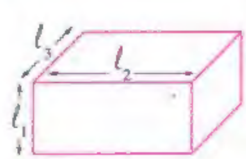
$\tan\theta = \dfrac{\sin\theta}{\cos\theta}$, $\sin(2\theta) = 2\sin\theta\cos\theta$

5 Perimeters, areas and volumes of some geometrical figures

A Plane geometrical figures

Geometrical figure	Square	Rectangle	Triangle	Circle
Figure shape				
Perimeter	4ℓ	$2(\ell_1 + \ell_2)$	$\ell_1 + \ell_2 + \ell_3$	$2\pi r$
Area	ℓ^2	$\ell_1 \times \ell_2$	$\frac{1}{2}\ell_1 \times h$	πr^2

B Solid geometrical figures

Geometrical figure	Cube	Cuboid	Sphere	Cylinder
Figure shape				
Volume	ℓ^3	$\ell_1 \times \ell_2 \times \ell_3$	$\frac{4}{3}\pi r^3$	$\pi r^2 \times h$

6 Rules of exponents

Rule	Example
$x^0 = 1$	$(2^0) = 1$
$x^1 = x$	$(-4)^1 = -4$
$x^{-m} = \frac{1}{x^m}$	$(3)^{-2} = \frac{1}{(3)^2} = \frac{1}{9}$
$(x^m)^n = x^{mn}$	$(2^2)^3 = (2)^{2\times 3} = (2)^6 = 64$
$(xy)^m = x^m y^m$	$(2 \times 3)^2 = (2)^2 \times (3)^2 = 36$
$\left(\frac{x}{y}\right)^m = \frac{x^m}{y^m}$	$\left(\frac{1}{3}\right)^2 = \frac{(1)^2}{(3)^2} = \frac{1}{9}$
$x^m x^n = x^{m+n}$	$(2)^3 \times (2)^{-2} = (2)^{3+(-2)} = (2)^1 = 2$
$\frac{x^m}{x^n} = x^{m-n}$	$\frac{(3)^4}{(3)^{-2}} = (3)^{4-(-2)} = (3)^6 = 729$
$x^{\frac{m}{n}} = \sqrt[n]{x^m}$	$(8)^{\frac{1}{3}} = \sqrt[3]{8} = 2$

7 Proportionality

Direct proportionality	Inverse proportionality
If $y = cx$	If $y = \frac{c}{x}$

Where (c) is a constant value and x changes from x_1 to x_2, so y changes from y_1 to y_2, so that

Direct proportionality	Inverse proportionality
$\frac{y_1}{y_2} = \frac{x_1}{x_2}$	$\frac{y_1}{y_2} = \frac{x_2}{x_1}$

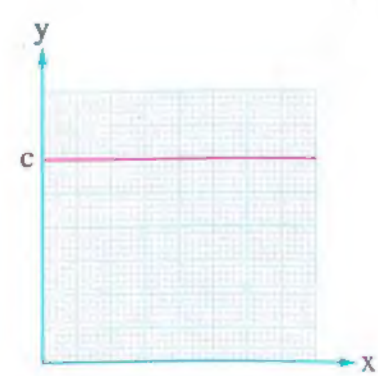
Similarly, when

$y^2 = cx$	$y = cx^2$	$y^2 = \frac{c}{x}$	$y = \frac{c}{x^2}$
Then		Then	
$\frac{y_1}{y_2} = \sqrt{\frac{x_1}{x_2}}$	$\frac{y_1}{y_2} = \frac{x_1^2}{x_2^2}$	$\frac{y_1}{y_2} = \sqrt{\frac{x_2}{x_1}}$	$\frac{y_1}{y_2} = \frac{x_2^2}{x_1^2}$

8 Graphical representation

A Constant function

If y = c where c is a constant value, it will be represented graphically by a straight line parallel to the horizontal axis (x-axis) whose slope equals zero.

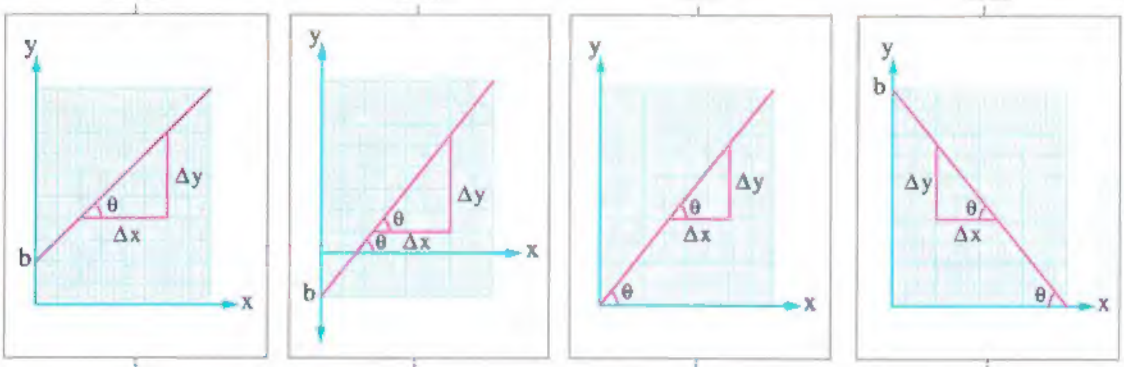


B Linear function

The general formula of the linear function
$y = \pm cx \pm b$

If

$y = cx + b$ $(c > 0 , b > 0)$	$y = cx - b$ $(c > 0 , b < 0)$	$y = cx$ Directly proportional $(c > 0 , b = 0)$	$y = -cx + b$ $(c < 0 , b > 0)$
then	then	then	then



Slope $= \tan\theta = \frac{\Delta y}{\Delta x} = \pm c$

*y-intercept (the point at which the function intersects the y-axis) $= \pm b$

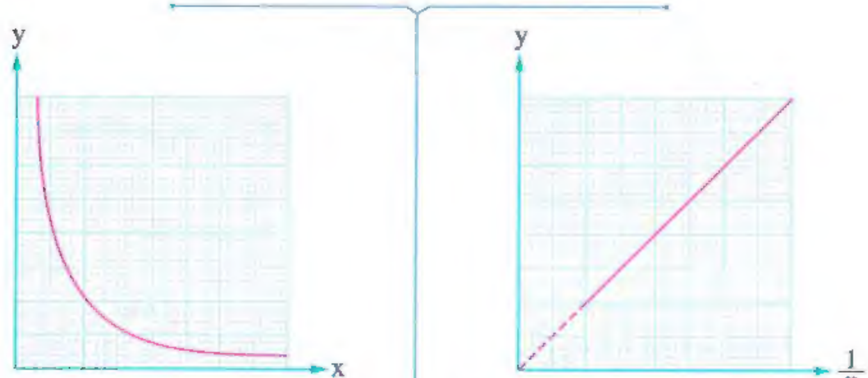
C Rational function (inversely proportional)

If $y = \frac{c}{x}$, where c is a constant value

Then the relation

(y-x) | $(y-\frac{1}{x})$

Represented graphically as follows



(Straight line whose slope equals c)

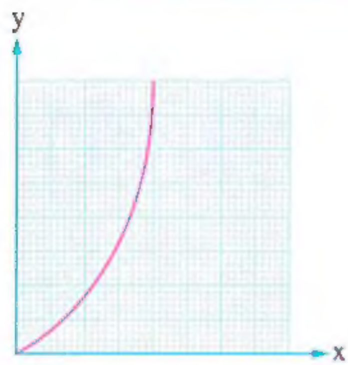
D Quadratic function

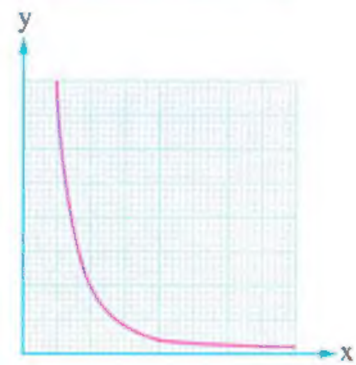
If

$y = c\,x^2$

$y = \dfrac{c}{x^2}$

Where (c) is a constant value, then the relation (y-x) is represented graphically as follows





The slope of the tangent at a point on the curve

Increases by increasing the value of x.

Decreases by increasing the value of x.

[illegible] with one unknown

1. Press MODE , the opposite screen appears.

2. Press EQN to choose the equation formula, the opposite screen appears such that the choice number denotes the equation formula as follows:

   1 First degree equation with two unknowns.
   2 First degree equation with three unknowns.
   3 Second degree equation with one unknown.
   4 Third degree equation with one unknown.

3. Press 3 to select the formula of the second degree equation with one unknown, the opposite screen appears, so we enter the coefficients of each variable separately by entering the value of a then press = , then the value of b and press = , then the value of c and press = , thus we see these data successively on the screen.

4. To get the value of the unknown x after entering all the coefficients, we press = so the value of x appears on the screen.

Unit One

Physical Quantities and Measuring Units

Chapters of the unit

Objectives of the unit

By the end of this unit, the student should be able to:

Chapter 1 :

- Distinguish the fundamental and derived physical quantities.
- Derive the dimensional formula of physical quantities.
- Determine the fundamental physical quantities in the International system and their units.
- Name the tools used to measure length, mass and time.
- Derive the international units of some derived physical quantities.
- Apply the dimensional formula to verify the physical relations.
- Identify how to calculate the error in the measurement
- Identify the reasons to have an error in measurement

Chapter 2

- Compare between the scalar and vector physical quantities
- Perform scalar (dot) product for vector quantities
- Perform vector (cross) product for vector quantities.

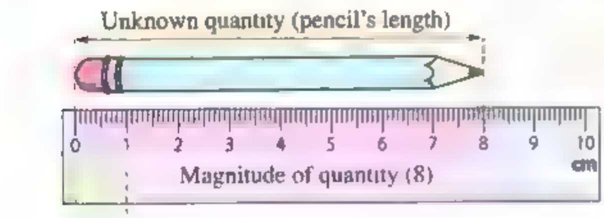
Chapter 1

Lesson One

Physical Measurements

- Measurements translate our daily observations into quantitative values that can be expressed in terms of numerals, **so to understand what is meant by the physical measurement**, let's take a look at the following example:

  When measuring the length of a pencil by a graduated ruler, we compare the pencil with the graduation of the ruler to know the length of the pencil:



Pencil's length	=	8	cm
The unknown quantity		The magnitude of the quantity	The measuring unit of the quantity

So, the measurement process can be defined as follows:

Measurement process :

It is the process of comparing an unknown quantity with another known quantity of its kind to find out how many times the first includes the second.

- **From the previous example, the key elements of measurement process can be illustrated as follows:**

Physical quantities | **Measuring tools** | **Measuring units**

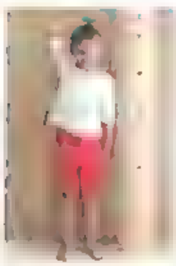
First Physical quantities

- The quantities that we deal with in our daily life such as mass, length, time, volume ... etc. are called physical quantities and these quantities can be classified into :

Fundamental quantities

1 They are physical quantities that **cannot be defined** in terms of other physical quantities, **for example:**

Length (ℓ)



Mass (m)

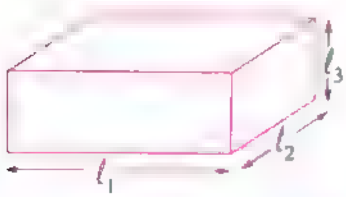
Time (t)

Derived quantities

2 They are physical quantities that can be defined in terms of the fundamental physical quantities, **for example:**

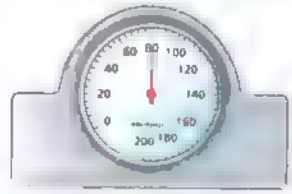
Volume (V)

Derived from length (ℓ).



Speed (v)

Derived from length (ℓ) and time (t).



[illegible]

- Physical quantities and their relationships to each other can be expressed by **mathematical equations.**

▸ **For example:**

When a moving body covers a distance (s) in time (t), its speed (v) can be expressed as:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} \quad \text{Or } v = \frac{s}{t}$$

and this relation is a shorthand formula to give a physical illustration of a particular indication (physical meaning).

Test yourself

Answered

One of the physical quantities is the density and its measuring unit is kg/m^3.
Is this quantity fundamental or derived?

....

Second Measuring tools

In ancient times

Humans used parts of the human body and also some natural phenomena as measuring tools such as:

- the arm, the hand span and the foot as tools to measure length.
- sunrise, sunset and Moon phases to measure time.

Recently

Measuring tools have been tremendously developed in the context of the great industrial revolution following the Second World War. Consequently, these tools were very helpful to humankind in accurately describing and exploring phenomena.

- The used measuring tool depends on the physical quantity to be measured, so the first step to measure any physical quantity is to choose the suitable measuring tool.

The next section shows some tools used for measuring (length, mass and time):

1 Length

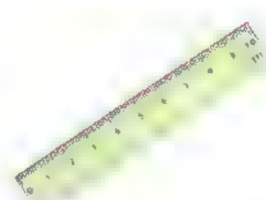
* Some measuring tools of length:

Meter tape

It is suitable for measuring lengths such as the dimensions of a room or the length of a door.

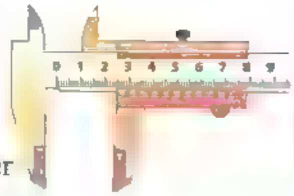
Ruler

It is suitable for measuring lengths such as the length of a book.



Vernier caliper

It is used in measuring small lengths with high accuracy **such as** measuring the diameter of a pen or the diameter of a small metallic sphere.



Micrometer

It is used in measuring very small lengths with high accuracy **such as** measuring the thickness of a sheet or the thickness of a wire.

* **Some examples of measured lengths:**

The distance between the Sun and the closest star to it = 4×10^{16} m

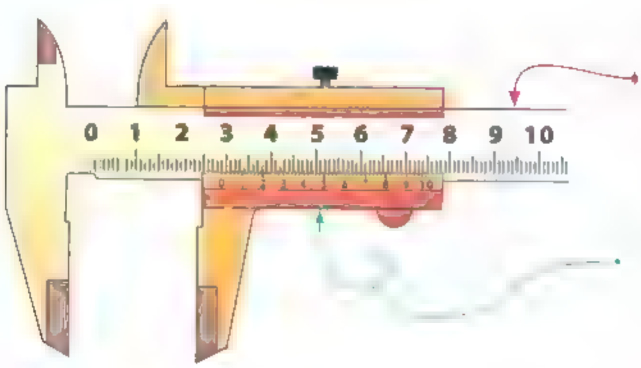
The average of the Earth's radius = 6.37×10^{6} m

The length of soccer field = 91 m

The diameter of the nucleus of the atom ≈ 10^{-14} m

Vernier caliper

Its structure



Fixed scale

(One division = 1 mm)

Sliding (vernier) scale

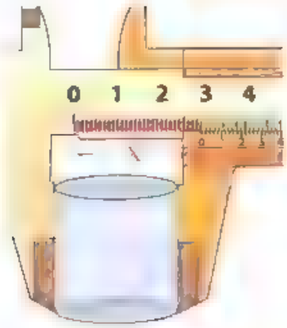
It moves along the fixed scale and it is graduated into a number of divisions (One division = 0.9 mm)

Note :

- The millimeter (mm) is the measuring unit for the very small lengths and it equals 10^{-3} m.

How it is used

1. The object is placed between the two jaws of the caliper and gently pressed.

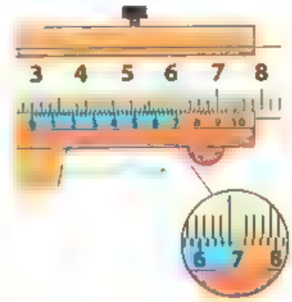


2. The length of the object is determined from the relation :

The length = X + x

Where: (X) is the reading on the fixed scale which is recorded before the zero mark of the vernier scale.

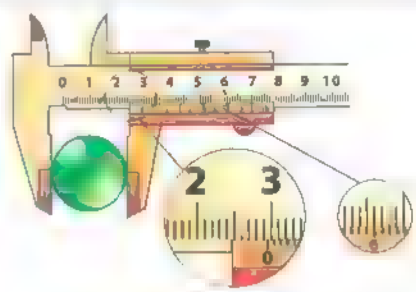
(x) is the vernier reading which is determined by finding out the mark on the vernier scale that perfectly lines up with one of the marks on the fixed scale and multiplying it by the difference between the divisions on the fixed scale and the divisions on the vernier scale (i.e., multiplying it by 0.1 mm).



Example

Using the opposite figure, the external diameter of the ball is ....

ⓐ 29 mm ⓑ 29.1 mm
ⓒ 29.6 mm ⓓ 35 mm



Solution

The fixed scale reading (X) = 29 mm

The vernier scale reading (x):

x = 6 × 0.1 = 0.6 mm

∴ The measured length (the external diameter of the ball) = X + x = 29 + 0.6 = 29.6 mm

∴ **The correct choice is ⓒ.**

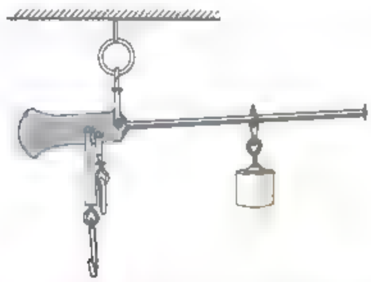
What if you are asked to measure the external diameter of the ball by using the ruler, will the measurement be more accurate in this case?

2 Mass

* Some measuring tools of mass:

Roman balance

It was used in ancient times to measure the mass, but it has large percentage of error when measuring the relatively small masses (for example 2 kg) and it can be used in measuring the mass of a sack of potatoes.



Two pan balance

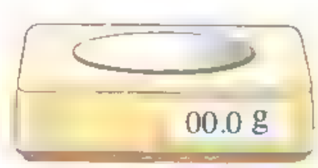
It is used in measuring masses in kilograms depending on their equilibrium with loads of known masses **such as** measuring the mass of vegetables or fruits.

One pan balance

It is used in measuring the mass in kilogram **such as** measuring the mass of vegetables and fruits.

Digital balance

It is used in measuring the very small masses with high accuracy **such as** measuring the masses of golden accessories.



* Some examples of measured masses:

The mass of the Milky Way galaxy $\simeq 10^{42}$ kg

The mass of Saturn $\simeq 5.7 \times 10^{26}$ kg

The mass of a frog $\simeq 0.022$ kg

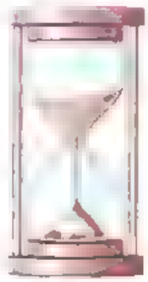
The mass of the electron $\simeq 9.1 \times 10^{-31}$ kg

3 Time

* **Some measuring tools of time:**

Hourglass

One of the oldest tools to determine the time, in which sand flows from the upper bulb to the lower bulb during a certain time that is specified when designing it.



Pendulum clock

It depends in its measuring of time on energy conservation law of a pendulum that swings by a small angle.

Stopwatch

It is used to measure a finite interval of time **such as** measuring the time taken by a racer to finish a race or the time taken by a body to fall from the top of a building.

Digital watch

It is used to determine the time and it is one of the newest tools that is used in our daily life.

* **Some examples of measured times:**

The age of universe = 4×10^{17} s

The time of a day = 8.64×10^{4} s

The interval of time between the heart beats = 0.8 s

2 Test yourself

Answered

Choose the correct answer:

What are the two suitable tools for measuring the length and the diameter of a metal wire respectively?

(a) Micrometer, vernier caliper
(b) Meter tape, micrometer
(c) Ruler, meter tape
(d) Vernier caliper, ruler

Third : Measuring units

• Each physical quantity, either fundamental or derived, has a measuring unit to identify it because a quantity without its unit of measurement is meaningless, **for example:**

The mass of a body = 5

The value is meaningless because it has no measuring unit to identify it.

The mass of a body = 5 kg

The quantity is fully clarified because there is a unit of measurement to identify it.

Note :

• Some physical quantities have no measuring units like relative density and refractive index and that is because they are equal to the quotient of two quantities of the same kind.

* **There are multiple systems to specify the measuring units of the fundamental physical quantities such as:**

1. The French **system.**
2. The British **system.**
3. The Metric **system.**

➲ The following table shows the used measuring units in each of the French, the British and the Metric systems:

System of units / The fundamental physical quantity	Units of measurement		
	The French system (Gaussian system) (C.G.S)	**The British system (F.P.S)**	**The Metric system (M.K.S)**
Length (l)	Centimeter (cm)	Foot (ft)	Meter (m)
Mass (m)	Gram (g)	Pound (lb)	Kilogram (kg)
Time (t)	Second (s)	Second (s)	Second (s)

International system of units (SI units)

* In the General Conference of Weights and Measures in 1960, scientists agreed to add other four fundamental physical quantities to the Metric system to have an international system of units used in all scientific fields all over the world which means that the scientists can communicate by using one scientific language.

➲ The following table shows the used measuring units of the fundamental physical quantities in the international system:

The physical quantity	The international unit
1 Length (ℓ)	Meter (m)
2 Mass (m)	Kilogram (kg)
3 Time (t)	Second (s)
4 Electric current intensity (I)	Ampere (A)
5 Absolute temperature (T)	Kelvin (K)
6 Amount of substance (n)	Mole (mol)
7 Luminous intensity (I_v)	Candela (cd)

Then, two other units are added which are:

8 Plane angle	Radian (rad)
9 Solid angle	Steradian (sr)

* All other SI units can be derived from the previous fundamental (base) units, **for example:**

Volume
of measuring unit (m^3)

Derived from

Length
of measuring unit (m)

Speed
of measuring unit (m/s)

Derived from

Length
of measuring unit (m)

Time
of measuring unit (s)

Note :

• Some physical quantities have equivalent units, **for example:**

	Force	Energy	Pressure	Quantity of electric charge
Measured in →	Newton (N)	Joule (J)	Pascal (Pa)	Coulomb (C)
Equivalent to →	$kg.m/s^2$	$kg.m^2/s^2$	$kg/m.s^2$	A.s

Standard Units

- Scientists sought the most accurate definition for each fundamental measuring unit by preparing an ideal model for the measuring unit that is characterized by the maximum level of accuracy and stability against time and environmental changes. These models are called **the standard units.**

Examples of these standard units are:

1 The standard length (The standard meter)

- French people were the first who used the meter as a standard unit for measuring the length.

The standard meter is the distance between two engraved marks at the ends of a rod made of platinum and iridium alloy kept at 0°C, at the International Bureau of Weights and Measures near Paris.

2 The standard mass (The standard kilogram)

- It is used to calibrate the unit of measuring mass (the kilogram).

The standard kilogram is the mass of a cylinder made of platinum and iridium alloy of specific dimensions kept at 0°C, at the International Bureau of Weights and Measures near Paris.

Note :

- **Platinum and iridium alloy is used in making standard meter and standard kilogram instead of other materials such as glass** because platinum and iridium alloy is rigid, chemically inactive and not affected by the surrounding temperature contrary to the other materials.

3 The standard time (The second)

In ancient times

Daytime and **nighttime** were taken to figure out an easy and acceptable measure for the time unit where :

Solar day = 24 hours, an hour = 60 minutes and a minute = 60 seconds

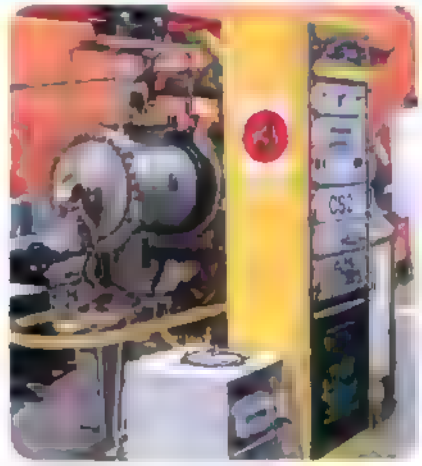
$\therefore$ Seconds found in the average solar day = $24 \times 60 \times 60 = 86400$ seconds

Recently

Scientists use the **atomic clocks** such as the cesium clock to calibrate the second because of their high accuracy.

◎ **The cesium atomic clock is used for :**

- Determining the duration of the Earth spin (the day length).
- Tuning up the clocks used for aviation and navigations.
- Synchronizing the devices used in space ships that explore the universe.



The cesium atomic clock

Enrichment information

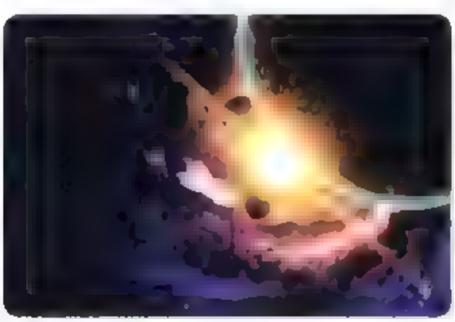
- Scientists defined the second by using the cesium atomic clock as follows:
  It is the interval of time spent by the cesium atom (atomic mass 133) to emit a certain number of waves, specifically 9192631700 waves.

Multiples and fractions of units in the International system

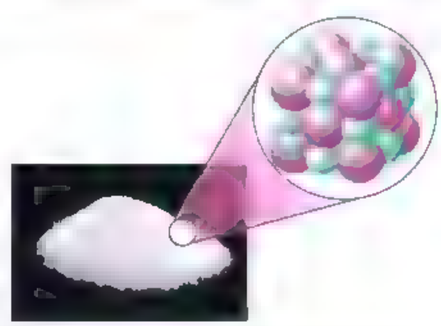
◎ A physical quantity is usually described by a numeral and a unit of measurement, but in some cases these values are:

Very huge (Or) **Very minute**

For example, the distance between the stars (it is nearly 100,000,000,000,000,000 m)



For example, the distance between the atoms in solids (it is nearly 0.000000001 m)



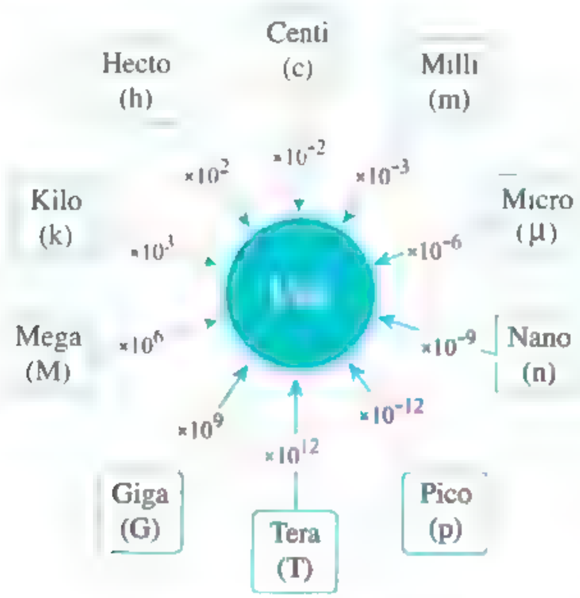
◎ Since it is very difficult to read such values. We prefer to express these values in the form of power of 10, so:

- The distance between the stars can be written as (**1×10^{17} m**).
- The distance between the atoms in solids can be written as (**1×10^{-9} m**).

A certain magnitude is written in the standard form as follows:

This way of expressing the magnitude of physical quantities is known as "**the standard form**".

The factors $10^{\pm x}$ are given specific prefixes, as shown in the following diagram:



- It's easy in the international system of units to calculate the multiples and fractions of all the measuring units in the form of power of 10 than for the other systems of units.

Notes :

1. **Liter (L)** is the measuring unit of the volume of liquids and gases and it is equivalent to 10^{-3} m^3.
2. **Angstrom (Å)** is the measuring unit of the very small lengths like the radii of the atoms and it is equivalent to 10^{-10} m.
3. **Gram (g)** is the measuring unit of the small masses and it is equivalent to 10^{-3} kg.
4. **Ton (ton)** is the measuring unit of the large masses and it is equivalent to 10^3 kg.

(5) If two physical quantities of the same type have different measuring units, one unit should be converted into the other unit before performing any calculations on them, **for example:**

$$1\ \text{m} + 170\ \text{cm} = \begin{cases} 1\ \text{m} + 1.7\ \text{m} = 2.7\ \text{m} \\ 100\ \text{cm} + 170\ \text{cm} = 270\ \text{cm} \end{cases} \qquad 2.7\ \text{m} = 270\ \text{cm}$$

Distinguished Scientists

Ahmed Zewail:

An Egyptian scientist, who won Nobel Prize in 1999 for using a laser camera to study the mechanisms of chemical reactions between molecules that take place in a very short time, estimated by femto-seconds (fs = 10^{-15}s).

Ahmed Zewail

The steps of conversion of units

⊙ **If the units aren't raised to a power, such as:**

$$5\ \text{km} = \cdots\cdots\ \text{mm}$$

1. Convert the magnitude of the quantity with the known unit to its magnitude with the international unit:
   $5\ \text{km} = 5 \times 10^3\ \text{m}$

2. Convert the magnitude of the quantity from the international unit to its magnitude in the required unit:
   $5 \times 10^3\ \text{m} = 5 \times 10^3 \times 10^3\ \text{mm} = 5 \times 10^6\ \text{mm}$

> **[illegible]**
>
> You can revise the rules of exponents from section (6) page 11.

⊙ **If the units are raised to a power, such as:**

$$3\ \text{cm}^3 = \cdots\cdots\ \text{km}^3$$

1. Convert the magnitude of the quantity in the known unit to its magnitude in the international unit by raising the conversion coefficient to the same power of the unit:
   $3\ \text{cm}^3 = 3 \times (10^{-2}\ \text{m})^3 = 3 \times 10^{-6}\ \text{m}^3$

2. Convert the magnitude of the quantity from the international unit to its magnitude in the required unit by raising the conversion coefficient to the same power of the unit:

$$3 \times 10^{-6}\ m^3 = 3 \times 10^{-6} \times (10^{-3}\ km)^3$$
$$= 3 \times 10^{-6} \times 10^{-9}\ km^3$$
$$= \mathbf{3 \times 10^{-15}\ km^3}$$

(•) If the units are complex (consist of more than one measuring unit), such as:

2 km/h = ... m/s

Convert the magnitude of the quantity of the known unit to its magnitude in the required unit either in the numerator or the denominator using the previous steps:

$$2\ km/h = 2\ \frac{km}{h} = 2 \times \frac{10^3}{60 \times 60}\ \frac{m}{s} = \frac{5}{9}\ m/s$$

Example 1

A car moved a distance of 5 km, so this distance is equivalent to ....

ⓐ 5×10^{-5} cm ⓑ 5×10^{-2} cm ⓒ 5×10^{2} cm ⓓ 5×10^{5} cm

Solution

$s = 5\ km = 5 \times 10^3\ m = 5 \times 10^3 \times 10^2\ cm = \mathbf{5 \times 10^5\ cm}$

∴ **The correct choice is ⓓ.**

What if you are asked to find the distance in hectometer (hm) unit, **what** will be your answer?

Example 2

The length of a particle was measured using an instrument, it was found to be 3 μm, so the length of the particle equals ....

ⓐ 3×10^{9} km ⓑ 3×10^{3} km ⓒ 3×10^{-3} km ⓓ 3×10^{-9} km

Solution

$\ell = 3\ \mu m = 3 \times 10^{-6}\ m = 3 \times 10^{-6} \times 10^{-3}\ km = \mathbf{3 \times 10^{-9}\ km}$

∴ **The correct choice is ⓓ.**

What if you are asked to find the length of the particle in angstrom (Å) unit, **what** will be your answer?

Example 3

The Star of Africa diamond is the largest cut diamond in the world and it is kept in the tower of London. If the volume of this diamond is 30.2 cm^3, then its volume in m^3 equals ....

ⓐ 30.2×10^{3} ⓑ 30.2×10^{-2}

ⓒ 30.2×10^{-6} ⓓ 30.2×10^{-9}

Solution

$V = 30.2\ cm^3 = 30.2 \times (10^{-2}\ m)^3 = 30.2 \times 10^{-6}\ m^3$

∴ **The correct choice is ⓒ.**

What if you are asked to find the volume of the diamond in mm^3, **what** will be your answer?

Example 4

A car is moving on a highway at a speed of 37.5 m/s. If the maximum speed allowed on this road is 120 km/h, had the driver exceeded this speed?

ⓐ Yes, the speed of the car is higher than the allowed speed by 10 km/h

ⓑ Yes, the speed of the car is higher than the allowed speed by 15 km/h

ⓒ No, the speed of the car is lower than the allowed speed by 10 km/h

ⓓ No, the speed of the car is lower than the allowed speed by 15 km/h

Solution

Clue

To determine whether the driver exceeds the allowed speed or not, we should convert the car's speed from m/s to km/h and comparing it with the allowed speed.

$$v = 37.5\ m/s = 37.5\ \frac{m}{s} = 37.5\ \frac{10^{-3}}{\frac{1}{60} \times \frac{1}{60}}\ \frac{km}{h} = 135\ km/h$$

∴ The driver exceeds the allowed speed by (Δv):

$\Delta v = 135 - 120 = 15\ km/h$ ∴ **The correct choice is ⓑ.**

Note:

- The measuring unit of speed km/h can be converted into m/s as shown:

$$m/s \xrightarrow{\times \frac{18}{5}} km/h \qquad km/h \xrightarrow{\times \frac{5}{18}} m/s$$

What if you are asked to express the maximum allowed speed in m/s, **what** will be your answer?

3 Test yourself

Answered

Choose the correct answer:

✳ According to one of the theories the age of the universe is estimated to be approximately 14 billion years, so the age of the universe in seconds is ....
(Knowing that: The solar year = 365.25 days)

ⓐ 5.3×10^{19} s ⓑ 3.57×10^{19} s ⓒ 2.7×10^{18} s ⓓ 4.42×10^{17} s

Dimensional formula

- Scientists considered a method to define most of the physical quantities by expressing them in terms of the dimensions of the fundamental physical quantities such that:

Mass	Length	Time
is denoted by	is denoted by	is denoted by
M	L	T

, and when we express the physical quantities in terms of the symbols (M, L and T) where each of them has a certain exponent (a, b, c) we get the **dimensional formula** of the quantity.

The general dimensional formula of any physical quantity is:

The brackets [ ] are used to express the dimensional formula

The exponents of the dimensions

$$[A] = M^{\pm a} \; L^{\pm b} \; T^{\pm c}$$

The physical quantity

The dimension of the mass

The dimension of the length

The dimension of the time

Note:

- Some physical quantities differ in their descriptions such as length, height and diameter, but they all have the same dimensional formula.

How to deduce the dimensional formula

➲ The following table shows how to deduce the dimensional formula of the speed (v) as an example:

	Example
❶ Write down the mathematical relation that determines the given physical quantity.	$v = \frac{\text{Distance}}{\text{Time}} = \frac{s}{t}$
❷ Write down the relation in terms of the dimensions of the fundamental physical quantities (M, L and T).	$[v] = \frac{L}{T}$
❸ Put on each of the symbols M, L and T its suitable power. If one of the physical quantities mass, length or time is not present in the formula, it can be expressed as M^0, L^0 or T^0 such that $x^0 = 1$, so it is not written. • The measuring unit of the physical quantity can be obtained from the dimensional formula and vice versa.	$[v] = M^0 L T^{-1}$ $= L T^{-1}$ The measuring unit of speed is : $m.s^{-1}$ **Or** m/s

Notes :

1. To add or subtract two physical quantities, they must be of the same kind which means they must have the same dimensional formula and the same unit, **for example:** We can't add or subtract mass (5 kg) with distance (7 m) or speed (3 m/s) with energy (10 J).

2. We can multiply or divide physical quantities of different dimensional formula and in this case a new physical quantity can be obtained, **for example:**
   - By multiplying speed and time, we get another physical quantity which is the "distance".

   $$\text{Speed} \times \text{Time} = \text{Distance}$$

   - By dividing speed over time, we get another physical quantity which is the "acceleration".

   $$\frac{\text{Speed}}{\text{Time}} = \text{Acceleration}$$

3. Dimensional formulae **cannot be** added or subtracted but they **can be** multiplied or divided **for example:**
   - $LT^{-1} + LT^{-1} = LT^{-1} \neq 2\,LT^{-1}$
   - $LT^{-1} - LT^{-1} = LT^{-1} \neq 0$
   - $M \times LT^{-2} = M\,LT^{-2}$
   - $M\,LT^{-2} \div M = LT^{-2}$

4. Numerical constants (numerals) **such as** (π, 2, $\frac{1}{2}$) and trigonometric functions **such as** ($\sin\theta$, $\cos\theta$ and $\tan\theta$) have no measuring units and no dimensions.

➲ The following table shows the dimensional formulae of some derived physical quantities and their measuring units:

[illegible]	Its relationship to other quantities	The dimensional formula	Unit of measurement
Area (A)	A = Length × Width	$[A] = L \times L = L^2$	m^2
Volume (V)	V = Length × Width × Height	$[V] = L \times L \times L = L^3$	m^3
Density (ρ)	$\rho = \frac{\text{Mass}}{\text{Volume}}$	$[\rho] = M L^{-3}$	$kg.m^{-3}$
Speed (v)	$v = \frac{\text{Distance}}{\text{Time}}$	$[v] = L T^{-1}$	$m.s^{-1}$
Acceleration (a)	$a = \frac{\text{Change of speed}}{\text{Time}}$	$[a] = L T^{-2}$	$m.s^{-2}$
Force (F)	F = Mass × Acceleration	$[F] = M \times L T^{-2} = M L T^{-2}$	$kg.m.s^{-2}$
Momentum (P_L)	P_L = Mass × Speed	$[P_L] = M L T^{-1}$	$kg.m.s^{-1}$
Work (W)	W = Force × Displacement	$[W] = M L^2 T^{-2}$	$kg.m^2.s^{-2}$

Example 1

If the acceleration is defined as the time rate of change of speed, then the dimensions of acceleration (a) and its measuring unit are ....

	Dimensions	Measuring unit
ⓐ	LT^{-1}	$m.s^{-1}$
ⓑ	LT^{-1}	$m.s^{-2}$
ⓒ	LT^{-2}	$m.s^{-1}$
ⓓ	LT^{-2}	$m.s^{-2}$

Solution

$$\text{Acceleration} = \frac{\text{Change of speed}}{\text{Time}} = \frac{\text{Distance / Time}}{\text{Time}}$$

$$\therefore [a] = \frac{L/T}{T} = \frac{L T^{-1}}{T} = L T^{-2}$$

∴ The measuring unit of acceleration is $m.s^{-2}$.

∴ **The correct choice is ⓓ.**

Example 2

From the following equation: $x = C_1 t + C_2$ the measuring unit of the quantity C_1 is .... (Where: x is the distance in meter and t is the time in seconds)

ⓐ m　　ⓑ m.s　　ⓒ m/s　　ⓓ s/m

Solution

Clue

We can obtain the dimensions of the quantity C_1 by equalizing the dimensions of the two sides of the equation and taking into consideration that the dimensional formula doesn't be added.

$\because [x] = [C_1 t] = L$

$\because L = [C_1]\,T$　　　$\therefore [C_1] = \frac{L}{T} = L\,T^{-1}$

$\therefore$ The measuring unit of C_1 is meter/second (m/s).

$\therefore$ **The correct choice is ⓒ.**

What if you are asked to find the measuring unit of the quantity C_2, **what** will be your answer?

Example 3

In the opposite figure, a car moves with speed v on a curved path of radius r. If the acceleration of the car is calculated from the relation; $a = r^n v^m$ where m and n are numerical constants with no dimensions, then the values of m and n are ....

	m	n
ⓐ	1	–2
ⓑ	1	–1
ⓒ	2	–2
ⓓ	2	–1

Solution

$[a] = [r^n v^m]$

$L\,T^{-2} = L^n (L\,T^{-1})^m = L^n L^m T^{-m}$

$L\,T^{-2} = L^{n+m} T^{-m}$

By comparing the two sides of the equation : $n + m = 1$　,　$m = 2$

$\therefore n = -1$

$\therefore$ **The correct choice is ⓓ.**

You can revise the rules of exponents from section (6) page 11.

Test yourself

Answered

1 Choose the correct answer:

If the displacement (x) of a body is given from the relation; $x = At + B\sqrt{2t}$, where (t) is the time of motion, the dimensions of A and B are ....

	[A]	[B]
ⓐ	LT^{-1}	$LT^{\frac{1}{2}}$
ⓑ	LT	$LT^{\frac{1}{2}}$
ⓒ	LT^{-1}	$LT^{-\frac{1}{2}}$
ⓓ	LT	$LT^{-\frac{1}{2}}$

2 If the pressure is the division of the force by area, **find** the dimensions of the pressure. (Knowing that: Force (F) = Mass (m) × Acceleration (a), $[a] = LT^{-2}$)

....

....

The importance of the dimensional formula

The dimensional formula can be used to **verify the validity of a physical relation**. When applying the dimensional analysis, dimensions of both sides of the equation should match.

For example:

If we have any relation in the form of $X = Y$, we will have two possibilities:

If

The dimensional formula of X = The dimensional formula of Y

The dimensional formula of X ≠ The dimensional formula of Y

So

The relation may be correct.

The relation must be wrong.

Where

Having the same dimensions on both sides of a relation does not mean for sure that the relation is correct, because there may be numerical factors on any side of the equation that have no dimensions.

Different dimensions on both sides of the relation confirm that it is wrong.

Example 1

A body of mass m moves with speed v and its kinetic energy is K.E., so which of the following relations may be correct? *(Knowing that $[K.E] = ML^2T^{-2}$)*

ⓐ $K.E = \frac{1}{2} m^2 v$ ⓑ $K.E = 2\,mv$ ⓒ $K.E = \frac{1}{2} mv^2$ ⓓ $K.E = 2\,m^2v^2$

Solution

* The relation is possible when the dimensions of the sides of the equation are equal.

$\because$ The dimensions of the L.H.S : $[K.E] = M L^2 T^{-2}$

$\therefore$ The dimensions of the R.H.S must equal $M L^2 T^{-2}$

The dimensions of the R.H.S

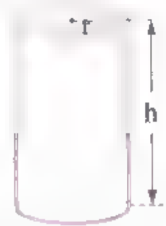
ⓐ	ⓑ	ⓒ	ⓓ
$[\frac{1}{2} m^2 v] = M^2 L T^{-1}$	$[2\,mv] = M L T^{-1}$	$[\frac{1}{2} mv^2] = M L^2 T^{-2}$	$[2\,m^2v^2] = M^2 L^2 T^{-2}$
✗	✗	✓	✗

$\therefore$ **The correct choice is ⓒ.**

What if $(\frac{1}{2})$ is removed from the choice ⓒ, will the dimensions of the R.H.S be the same or get changed?

Example 2

For a cylinder of base radius r, height h and volume V, which of the following relations may be correct?



ⓐ $V = \pi r h$ ⓑ $V = \pi r^2 h$ ⓒ $V = \pi \frac{r}{h}$ ⓓ $V = 2\pi \frac{h^2}{r}$

Solution

* The relation is possible when the dimensions of the sides of the equation are equal.

$\because$ The dimensions of the L.H.S: $[V] = L^3$

$\therefore$ The dimensions of the R.H.S must equal L^3

The dimensions of the R.H.S

ⓐ	ⓑ	ⓒ	ⓓ
$[\pi r h] = L L = L^2$	$[\pi r^2 h] = L^2 L = L^3$	$[\pi \frac{r}{h}] = \frac{L}{L} = L^0$	$[2\pi \frac{h^2}{r}] = \frac{L^2}{L} = L$
✗	✓	✗	✗

$\therefore$ **The correct choice is ⓑ.**

Example 3

A body moves under the effect of the acceleration due to gravity (g) where its speed gets changed from v_i to v_f during time t, so which of the following relations could be correct?
(Knowing that: $[g] = L\,T^{-2}$, $[v] = L\,T^{-1}$)

ⓐ $v_f = v_i + gt$ ⓑ $v_f = v_i t + gt$ ⓒ $v_f = v_i + gt^2$ ⓓ $v_f = v_i t + gt^2$

Solution

* The relation is possible when the dimensions of all the sides of the equation are equal.

∵ The dimensions of the L.H.S: $[v_f] = L\,T^{-1}$

∴ The dimensions of the R.H.S must equal $L\,T^{-1}$

The dimensions of the R.H.S

ⓐ		ⓑ		ⓒ		ⓓ	
$[v_i] = L\,T^{-1}$	$[gt] = L\,T^{-2}\,T = L\,T^{-1}$	$[v_i\,t] = L\,T^{-1}\,T = L$	$[gt] = L\,T^{-2}\,T = L\,T^{-1}$	$[v_i] = L\,T^{-1}$	$[gt^2] = L\,T^{-2}\,T^2 = L$	$[v_i\,t] = L\,T^{-1}\,T = L$	$[gt^2] = L\,T^{-2}\,T^2 = L$
✓		✗		✗		✗	

∴ **The correct choice is ⓐ.**

5 Test yourself

Answered

Choose the correct answer:

There are three physical quantities x, y and z that have dimensions $M\,L\,T^{-1}$, $M\,L\,T^{-2}$ and T respectively, so which of the following relations may be correct?

ⓐ $z = x\,y$ ⓑ $z = \frac{x}{y}$ ⓒ $z = \frac{y}{x}$ ⓓ $z = \frac{y^2}{x}$

Chapter 1

Questions on Lesson One

Physical Measurements

To watch videos of how to solve questions use the App

GPS

interactive test

The questions signed by ✳ are answered in detail

Multiple choice questions

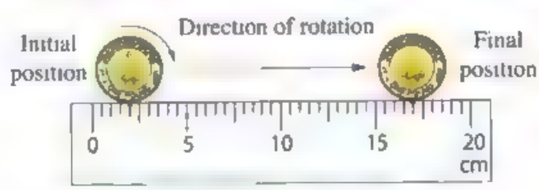
Physical measurements

1. The fundamental physical quantities from the following are ....
   - (a) the length and the area
   - (b) the velocity and the acceleration
   - (c) the mass and the volume
   - (d) the time and the mass

2. The derived physical quantities from the following are ....
   - (a) velocity - distance - time
   - (b) mass - density - volume
   - (c) work - force - distance
   - (d) force - volume - density

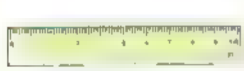
3. A common feature in the French (Gaussian) system, the British system and the Metric system is that they all measure ....
   - (a) length in meters
   - (b) mass in pounds
   - (c) time in seconds
   - (d) temperature in Celsius

4. ✳ In the following figure, a metallic coin rolls over a graduated ruler with a certain scale completing two rotations, so the circumference of the coin equals ....



   - (a) 6 cm
   - (b) 7.5 cm
   - (c) 15 cm
   - (d) 17 cm

5. The suitable tool for measuring the length of a room is ....

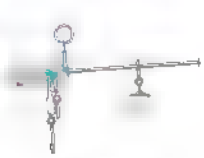

(a)


(b)


(c)


(d)

6. The suitable tool for measuring the mass of a golden ring is ....

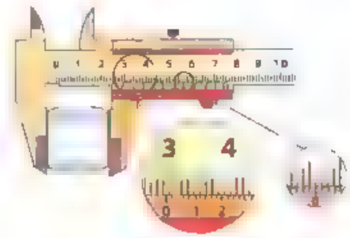

(a)


(b)


(c)


(d)

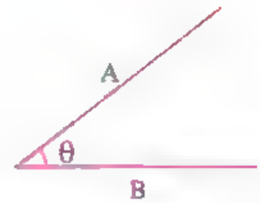
7 ✳ The opposite figure shows a vernier caliper while being used to measure the diameter of a solid metallic cylinder, then the diameter of the cylinder equals ....



ⓐ 2.96 mm ⓑ 3.26 mm
ⓒ 29.6 mm ⓓ 32.6 mm

International system of units

8 From the opposite figure:
The measuring unit of the confined angle (θ) between the two sides A, B in the international system of units is ....



ⓐ candela ⓑ radian
ⓒ steradian ⓓ meter

9 In which of the following choices do the length values increase from starting to ending?

ⓐ 1 cm ⟶ 1 nm ⟶ 1 mm ⟶ 1 μm ⓑ 1 μm ⟶ 1 mm ⟶ 1 nm ⟶ 1 cm
ⓒ 1 nm ⟶ 1 μm ⟶ 1 mm ⟶ 1 cm ⓓ 1 mm ⟶ 1 cm ⟶ 1 μm ⟶ 1 nm

10 ✳ Femtosecond = ... microsecond

ⓐ 10^{-15} ⓑ 10^{-9} ⓒ 10^{9} ⓓ 10^{6}

11 If the radius of the hydrogen atom is 0.053 nm, then it is equivalent to ....

ⓐ 0.53×10^{-10} m ⓑ 5.3×10^{-11} m ⓒ 53×10^{-12} m ⓓ all the previous

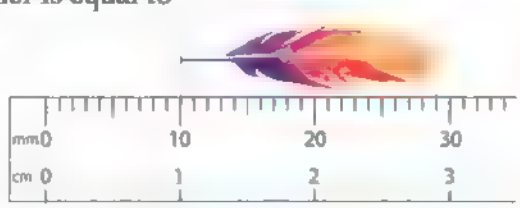
12 ✳ Which of the following values is equal to 86.2 mm?

ⓐ 862×10^{10} μm ⓑ 8.62×10^{-4} km ⓒ 0.862 Gm ⓓ 8.62 cm

13 If the volume of an amount of water equals 5 m^3, then its volume in liters equals ....

ⓐ 5 ⓑ 50 ⓒ 500 ⓓ 5000

14 ✳ In the following figure, a feather placed next to a ruler drawn with a certain scale, so the length of the feather is equal to ....



ⓐ 19×10^{6} nm ⓑ 29×10^{6} nm ⓒ 1.9 mm ⓓ 2.9 mm

15 ✳ If x = 10 g and y = 10 kg, then the value of (x + y) is ....

ⓐ 10.1 kg ⓑ 100.1 g ⓒ 10.01 kg ⓓ 10.01 g

16 The pyramid shown in the opposite figure contains about 2 million stones, the average mass of each stone is about 2.5 tons, then the mass of the pyramid equals ....

ⓐ 5×10^9 kg ⓑ 8×10^9 kg

ⓒ 5×10^{10} kg ⓓ 8×10^{10} kg

17 How many bottles of volume $10000\ cm^3$ is enough to fill a tank of capacity $1\ m^3$?

ⓐ 1 ⓑ 10 ⓒ 1000 ⓓ 100

18 If the speed of a car is $36\ km.h^{-1}$, it is equivalent to ....

ⓐ $10\ m.s^{-1}$ ⓑ $20\ m.s^{-1}$ ⓒ $36\ m.s^{-1}$ ⓓ $100\ m.s^{-1}$

Dimensional formula

19 If the measuring unit of a physical quantity is kg/m.s, then its dimensional formula is ....

ⓐ MLT ⓑ $ML^{-1}T^{-1}$ ⓒ $ML^{-1}T^2$ ⓓ MLT^2

20 If the dimensional formula of density is $ML^{-3}T^0$ and its measuring unit is kg^x/m^y, then ....

ⓐ $x = 1, y = 2$ ⓑ $x = 2, y = -1$ ⓒ $x = 1, y = 3$ ⓓ $x = 1, y = -3$

21 The opposite table shows the measuring units of some physical quantities, so if the dimensional formula of a specific physical quantity is $M^xL^xT^{-2x}$ where x is an integer number, the quantity may be the ....

The physical quantity	The measuring unit
Force	$kg.m/s^2$
Acceleration	m/s^2
Density	kg/m^3
Velocity	m/s

ⓐ force

ⓑ acceleration

ⓒ density

ⓓ velocity

22 If the dimensional formula of quantity A is ML^2T^{-2} and the dimensional formula of quantity B is ML^2T^{-2}, then the quantity (2B – A) ....

ⓐ has a dimensional formula of ML^2T^{-2}

ⓑ has a dimensional formula of $M^2L^4T^{-4}$

ⓒ has a dimensional formula of $M^3L^6T^{-6}$

ⓓ isn't a physical quantity

23 ✳ If $x = yz$ where the dimensional formula of physical quantity x is MLT^{-2} and the dimensional formula of physical quantity y is M^0LT^{-2}, so the dimensional formula of physical quantity z is ....

ⓐ MLT ⓑ ML^0T^0 ⓒ M^0LT ⓓ $M^{-1}LT$

24 ✳ If F is the force that acts on a static body of mass m to reach a speed v through time t, then the two physical quantities mv and Ft have ....

(Knowing that: $[F] = MLT^{-2}$, $[v] = LT^{-1}$)

ⓐ different dimensions

ⓑ the same dimensions

ⓒ different measuring units

ⓓ no meaning

25 ✳ The relative speed of a train moving at speed v_1 when the driver of another train moving in the opposite direction at speed v_2 observes it equals $(v_1 + v_2)$ while the relative density of a liquid equals the ratio between the density of the liquid and the density of water, then ....

	Relative speed	Relative density
ⓐ	has no dimensions	has no dimensions
ⓑ	has no dimensions	has dimensions
ⓒ	has dimensions	has no dimensions
ⓓ	has dimensions	has dimensions

26 ✳ If the equation $x = At^2 + Bt$ describes the motion of a body and the quantity x has the length dimension and the quantity t has the time dimension, then the dimensions of each of the quantities A and B are ....

	[A]	[B]
ⓐ	LT^2	LT
ⓑ	LT^2	LT^{-1}
ⓒ	LT^{-2}	LT^{-1}
ⓓ	LT^{-2}	LT

27 ✳ A body of initial velocity v_i starts its motion with uniform acceleration a to cover a displacement d through time (t) to reach a final velocity v_f after this time.
(Knowing that: $[a] = L T^{-2}$, $[v] = L T^{-1}$)

(i) Which of the following equations may be possible?

(a) $v_f^2 = v_i + at^2$ (b) $v_f^2 = v_i^2 + 2ad$ (c) $v_f^2 = v_i + 2ad$ (d) $v_f^2 = v_i^2 + a^2d$

(ii) Which of the following equations is confirmed to be wrong?

(a) $t = \frac{v_f - v_i}{a}$ (b) $\frac{d}{t} - v_i = \frac{1}{2}at$ (c) $\frac{v_f^2 - v_i^2}{d} = 2a$ (d) $d = v_i t^2 + \frac{1}{2}at$

Second Essay questions

1 Is the physical quantity that is measured by $kg.m^{-3}$ fundamental or derived quantity? And why?

2 Arrange in a descending order the following masses:

(1) 15 g (2) 0.032 kg (3) 2.7×10^5 mg
(4) 4.1×10^{-8} Gg (5) 2.7×10^8 µg

3 What is the importance of using (platinum - iridium) alloy in the standard meter?

4 Is the following statement valid? **Explain your answer**.
"The dimensional formula is used to prove that a rule is incorrect, but it is not enough to prove that the rule is correct".

5 Einstein states his famous equation: $E = mc^2$, where (c) is the speed of light, (m) is the mass of the particle and (E) is the energy. **Use this equation to deduce** the international system of units for measuring the energy of a particle (E).

6 Deduce the dimensions of each of the following:

(1) Force (F). (2) Pressure (P). (3) Work (W).

(Knowing that: Force (F) = Mass (m) × Acceleration (a), Pressure (P) = $\frac{\text{Force (F)}}{\text{Area (A)}}$, Work (W) = Force (F) × Displacement (d) and $[a] = L T^{-2}$)

7 Use the dimensional formula to check the possibility of the following laws:

(1) Work (W) = $\frac{1}{2}mv^2$ (2) Volume of a sphere (V_{ol}) = $\frac{4}{3}\pi r^3$
(3) Force (F) = $\frac{m}{V_{ol}}$ (4) Area of a square (A) = ℓ^3
(5) Velocity (v) = $a^2 t$

(Where: (v) is the body speed, (m) is the body mass, (r) is the sphere radius, (a) is the body acceleration, (ℓ) is the length of the square and (t) is the time)

Questions that measure high levels of thinking

Answered in detail

Choose the correct answer :

1. If the radius of Saturn is 5.85×10^7 m and its mass is 5.68×10^{26} kg, the average density of Saturn materials equals ....

(Knowing that: the volume of a sphere = $\frac{4}{3} \pi r^3$, the surface area of a sphere = $4 \pi r^2$, $\pi = \frac{22}{7}$ and (r) is the radius of the sphere)

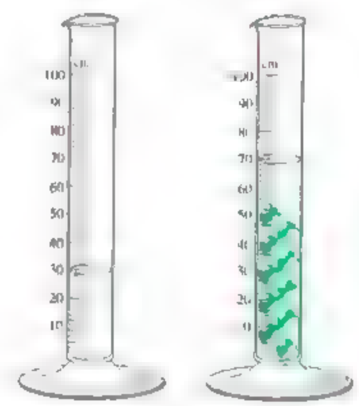
ⓐ 2.3×10^{15} g/cm^3 ⓑ 6.77×10^{-5} g/cm^3 ⓒ 6.77×10^{2} g/cm^3 ⓓ 0.677 g/cm^3

2. The opposite figure shows two identical cylinders (1) and (2), cylinder (1) contains a certain quantity of water and cylinder (2) contains the same quantity of water and ten identical solid glass marbles, the mass of each marble is 10 g, then the density of the glass of which these marbles are made is ....

(Given that : Density = $\frac{\text{Mass}}{\text{Volume}}$)

ⓐ 25×10^3 kg/m^3 ⓑ 4×10^2 kg/m^3

ⓒ 25×10^2 kg/m^3 ⓓ 4×10^3 kg/m^3



Cylinder (1) Cylinder (2)

3. The measuring unit of the physical quantity that has a dimensional formula of MLT^{-1} is ....

(Knowing that: The newton (N) is equivalent to kg.m.s^{-2}, the joule (J) is equivalent to kg.m^2.s^{-2})

ⓐ N.m ⓑ J.m^{-1} ⓒ N.s ⓓ J.s^{-1}

4. By using the opposite table:

What is the measuring unit of the quantity that equals the product of the gas pressure and its volume?

(Knowing that: The pressure is measured in pascal)

ⓐ Newton ⓑ Watt

ⓒ Newton.second ⓓ Joule

Measuring unit	Equivalent unit
Newton (N)	kg.m.s ^{2}
Pascal (Pa)	N/m^2
Joule (J)	N.m
Watt (W)	J/s

5 If Newton's universal law of gravitation is given by the relation: $F = \frac{GMm}{r^2}$, where F is the attraction force between two bodies of masses M and m and the distance between their centers is r, then the measuring unit of the universal gravitational constant (G) in terms of the international system of units is .... (Knowing that: $[F] = MLT^{-2}$)

ⓐ $kg.m^3.s^{-2}$ ⓑ $kg^{-1}.m^{-3}.s^{-2}$ ⓒ $kg^{-1}.m^3.s^{-2}$ ⓓ $kg.m^{-3}.s^{-2}$

6 The kinetic energy (K.E) of a body is given by the relation: $K.E = \frac{P^2}{2\,m}$, where P is the momentum of the body and m is its mass. If the measuring unit of kinetic energy is $kg.m^2/s^2$ and the measuring unit of the force is newton (N) and the dimensional formula of the force is MLT^{-2}, then the measuring unit of the momentum is ....

ⓐ $N^{-1}.s^{-1}$ ⓑ N.s ⓒ $N^2.s$ ⓓ $N^{-1}.s$

7 If the tension force in one of the strings of a musical instrument is F_T and the mass per unit length of the string is μ and the speed of the moving wave in this string is v, so which of the following equations may be correct? (Knowing that: $[F_T] = MLT^{-2}$, $[v] = LT^{-1}$)

ⓐ $v = \frac{F_T}{\sqrt{\mu}}$ ⓑ $v = F_T^2\,\mu$ ⓒ $v = \sqrt{\frac{F_T}{\mu}}$ ⓓ $v = F_T\,\mu^2$

8 The opposite table shows the dimensions of the physical quantities x, y, z and k.

The physical quantity	x	y	z	k
Dimensional formula	MLT^{-2}	LT^{-2}	M	MLT^{-2}

Which of the following equations may be correct?

ⓐ x = y + z + k ⓑ x = y + z k ⓒ x = y z k ⓓ x = y z + k

Answer the following questions :

9 The dimensional formula of both quantities X and Y is LT^{-1}, the dimensional formula of quantity Z is LT^{-2} and the dimensional formula of quantity K is L.

Use the previous quantities to form a possible relation.

Chapter 1

Lesson Two

Types of Measurement & Measurement Error

Measurement error

- Scientific and technological advancement led to the creation and the development of new measuring tools and increasing their accuracy but there must be an error even if it is a small percentage of error. So no measurement process is 100% accurate because of several reasons (sources) of measurement error, such as:

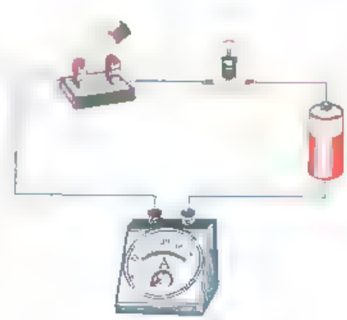
1. **Choosing an improper tool, for example:**

   Using the common balance instead of the sensitive balance in measuring the mass of a golden ring increases the percentage of measurement error.

Common balance

Sensitive balance

2. **A defect in the measuring tool as the defects that may be in the ammeter, for example:**
   - The magnet inside is partially demagnetized because it is outdated.
   - The pointer has a zero error when there is no electric current (zero error).



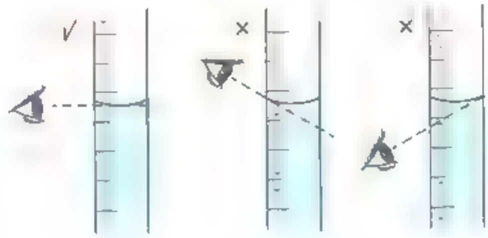
Ammeter

3. Wrong procedure due to the lack of experience of persons, for example:

- Ignorance or inexperience of using graduated devices **like** the multimeters.

Multimeter

- Looking at the device pointer or the scale at an oblique line instead of looking perpendicularly to the scale.



4. Environmental conditions, for example:

- Temperature.
- Humidity.
- Air currents, as when using the sensitive balance, the air currents may cause an error during the measurement process and to avoid this, the sensitive balance is kept inside a glass box.

The sensitive balance inside the glass box to avoid wind effect

Note :

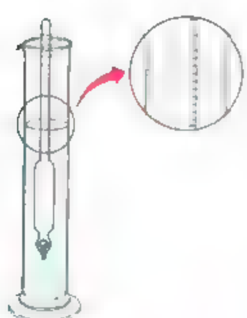
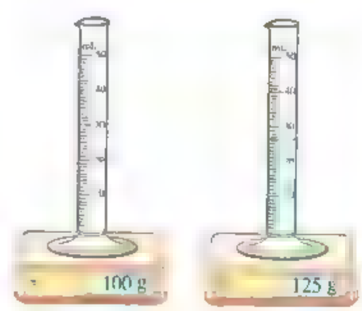
- **When carrying out a measuring process, it's preferable to repeat the measurement many times and calculate the average** to reduce the error percentage in the measurement and the average of readings is calculated as follows:

$$\text{Average of readings} = \frac{\text{Sum of readings}}{\text{The number of taking readings for the measured quantity}}$$

For example: When measuring the height of a building (h) for three times, they were found to be 100 m, 101 m and 99 m, then:

∴ The average of the measured height for the building (h) $= \frac{100 + 99 + 101}{3} = 100$ m

Types of measurement

	Direct measurement	Indirect measurement
The number of measuring processes	One measuring process	More than one measuring process
The calculations	We don't substitute in a mathematical relation	We substitute in a mathematical relation
The error in measurement	It leads to one error in the measuring process	It leads to more than one error in the measuring process which is known as error accumulation
Example	Measuring the liquid density using the hydrometer in which we take a direct reading without calculation or substituting in any mathematical relation. 	Determining the liquid density via measuring its mass by a balance and its volume by a graduated cylinder. Then, calculating the density from the relation; $\text{Density} = \frac{\text{Mass}}{\text{Volume}}$ 

Estimating error of measurement

⊙ **The error in measurement is estimated by calculating:**

1 Absolute error (Δx)

▸ It is the difference between the real (actual) value (x_o) and the measured value (x).

2 Relative error (r)

▸ It is the ratio between the absolute error (Δx) and the real value (x_o).

Rule

$$\Delta x = |x_o - x|$$

$$r = \frac{\Delta x}{x_o}$$

Measuring unit

- Has a measuring unit which is the same measuring unit of the measured physical quantity.
- Has no measuring unit because it is a ratio between two quantities having the same measuring unit.

Notes

- The sign of modulus | | gives the absolute value which indicates that the result is always **positive** even if the actual value is less than the measured value (for example: $|-8| = 8$) because the aim of estimating the absolute error is only knowing its value.
- The relative error is **a better indication** for the measurement accuracy than the absolute error because it is the ratio between the absolute error and the real value.
- The measurement accuracy is considered **higher** as the relative error **decreases.**
- The percentage of error equals $r \times 100$

⊙ The result of the measurement process is expressed as $X = (X_o \pm \Delta X)$.

⊙ **Now, we will know how to calculate the absolute error and the relative error in case of direct and indirect measurement processes.**

1 Estimating error in the direct measurement

The **absolute error** is directly calculated from the relation:

$$\Delta X = |X_o - X| = r\,X_o$$

The **relative error** is directly calculated from the relation:

$$r = \frac{\Delta X}{X_o} = \frac{|X_o - X|}{X_o}$$

Example

A student measured the length of a pencil and found it equal to 9.9 cm, meanwhile its actual length is 10 cm. Another student measured the classroom length and found it equal to 9.13 m, meanwhile its actual length is 9.11 m.

(a) *Estimate* the absolute error and the relative error in each case *and express* the result of measurement process.

(b) *In which case* was the measurement more accurate? *And why*?

Solution

(a)

First student	Second student

Absolute error

First student	Second student
$\Delta x = \lvert x_0 - x \rvert$	$\Delta x = \lvert x_0 - x \rvert$
$= \lvert 10 - 9.9 \rvert$	$= \lvert 9.11 - 9.13 \rvert$
$= 0.1$ cm	$= \lvert -0.02 \rvert = 0.02$ m

Relative error

First student	Second student
$r = \frac{\Delta x}{x_0} = \frac{0.1}{10} = 0.01$	$r = \frac{\Delta x}{x_0} = \frac{0.02}{9.11} = 0.0022$

Expressing the result of measurement

First student	Second student
The length of the pencil $= (10 \pm 0.1)$ cm	The length of the classroom $= (9.11 \pm 0.02)$ m

(b) The measurement in the second case is more accurate because the relative error in the second case is less than that in the first case.

1 Test yourself

Answered

Choose the correct answer:

If the real mass of the watermelon in the opposite figure is 3.522 kg and the real mass of the apple is 0.159 kg, then ....

1 2

(a) balance (1) is more accurate

(b) balance (2) is more accurate

(c) the two balances have the same accuracy and it doesn't equal 100 %

(d) the two balances have the same accuracy and it equals 100 %

UNIT 1

Estimating error in the indirect measurement

The procedure of calculating error in the case of indirect measurement depends on the mathematical operation applied as shown in the following table:

A Addition and subtraction operations

[illegible]	Example	How to calculate error
Addition ⊕	Measuring the total volume of two amounts of a liquid. $$V = V_1 + V_2$$	❶ The absolute error = The absolute error in first measurement + The absolute error in second measurement $$\Delta x = \Delta x_1 + \Delta x_2$$ $$= \lvert x_{o1} - x_1 \rvert + \lvert x_{o2} - x_2 \rvert$$ *Or* $$\Delta x = r\, x_o$$
Subtraction ⊖	Finding the volume of a metallic coin by subtracting the volume of water before dropping the metallic coin into the measuring cylinder (V_1) from that after dropping it (V_2). $$V_{\text{metallic coin}} = V_2 - V_1$$	❷ The relative error (r) = $\dfrac{\text{The absolute error}}{\text{The real value}}$ $$r = \frac{\Delta x}{x_o}$$

Example 1

In a practical experiment to determine a physical quantity (L) by adding two physical quantities L_1 and L_2 given that $L_1 = (5.2 \pm 0.1)$ cm and $L_2 = (5.8 \pm 0.2)$ cm.

So, the value of (L) and the relative error in measuring it are ....

	Value of L (cm)	The relative error in measuring L
ⓐ	0.6 ± 0.02	$\frac{1}{550}$
ⓑ	11 ± 0.3	$\frac{33}{10}$
ⓒ	11 ± 0.02	$\frac{11}{50}$
ⓓ	11 ± 0.3	$\frac{3}{110}$

Solution

$\because$ The real value of (L): $L_o = 5.2 + 5.8 = 11$ cm

$\because$ The absolute error: $\Delta L = 0.1 + 0.2 = 0.3$ cm

$\therefore$ **The value of (L):** $L = (L_o \pm \Delta L) = (11 \pm 0.3)$ **cm**

$\therefore$ **The relative error:** $r = \frac{\Delta L}{L_o} = \frac{0.3}{11} = \frac{3}{110}$

$\therefore$ **The correct choice is ⓓ.**

Example 2

A student measured the mass of an amount of a chemical material, it was found to be (20 ± 0.1) g, then the mass of the material was decreased by (5 ± 0.1) g. So, the mass of the remaining amount of the material equals

ⓐ (15 ± 0) g ⓑ (15 ± 0.2) g ⓒ (25 ± 0.2) g ⓓ (4 ± 1) g

Solution

$\therefore$ The real value of the remaining mass: $m_o = m_1 - m_2 = 20 - 5 = 15$ g

$\therefore$ The absolute error: $\Delta m = \Delta m_1 + \Delta m_2 = 0.1 + 0.1 = 0.2$ g

$m = (m_o \pm \Delta m) = (15 \pm 0.2)$ **g**

$\therefore$ **The correct choice is ⓑ.**

What if you are asked to calculate the relative error in measuring the remaining mass, **what** will be your answer?

2 Test yourself

Answered

Choose the correct answer:

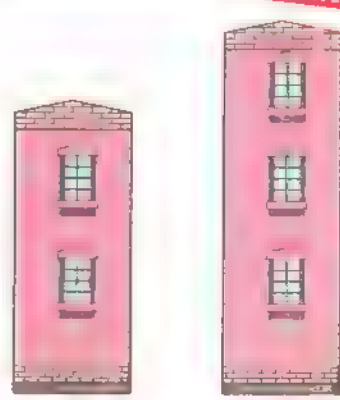
If the height of building (1) equals (8 ± 0.2) m and the height of building (2) equals (12 ± 0.2) m, so building (2) is taller than building (1) by ……… .

ⓐ (20 ± 0.4) m

ⓑ (20 ± 0) m

ⓒ (4 ± 0.4) m

ⓓ (4 ± 0) m



1 2

B Multiplication and division operations

[illegible]	Example	How to calculate error
Multiplication ⊗	Finding the area of a rectangle by measuring its length and its width then multiplying them.	❶ The relative error = The relative error in the first measurement + The relative error in the second measurement $r = r_1 + r_2 = \frac{\Delta x_1}{x_{o1}} + \frac{\Delta x_2}{x_{o2}}$
Division ⊘	Finding the density of a liquid by measuring its mass and its volume then dividing them.	❷ The absolute error (Δx) = The relative error × The real value $\Delta x = r x_o$

Example 1

The relative error and the absolute error when measuring the area of a rectangle (A) that has a length of (6 ± 0.1) m and a width of (5 ± 0.2) m are .... , ...

	Relative error	Absolute error
ⓐ	$\frac{7}{300}$	1.7 m^2
ⓑ	$\frac{7}{300}$	0.07 m^2
ⓒ	$\frac{17}{300}$	1.7 m^2
ⓓ	$\frac{17}{300}$	0.07 m^2

Solution

Clue

The area of the rectangle (A) is determined by multiplying the length (x) by the width (y), so the measurement process is indirect. We can find the relative error in measuring the area of the rectangle from the relation:

$$r_A = r_x + r_y \quad , \quad r_x = \frac{\Delta x}{x_o} \quad , \quad r_y = \frac{\Delta y}{y_o}$$

, and also we can calculate the absolute error in measuring the area of the rectangle from the relation: $\Delta A = r_A A_o$, (Where: $A_o = x_o y_o$)

∵ The relative error in measuring:

The length	The width
$r_x = \frac{\Delta x}{x_o} = \frac{0.1}{6}$	$r_y = \frac{\Delta y}{y_o} = \frac{0.2}{5}$

∴ The relative error in measuring the area:

$$r_A = \frac{0.1}{6} + \frac{0.2}{5} = \frac{17}{300}$$

∴ The absolute error in measuring the area:

$$\Delta A = \left(\frac{17}{300}\right) \times (5 \times 6) = 1.7 \text{ m}^2$$

∴ **The correct choice is ⓒ.**

What if you are asked to calculate the percentage of error in measuring the perimeter of the rectangle?

Example 2

The volume of a cuboid that has the dimensions shown in the opposite table is ....

Dimension	Measured value (cm)	Actual value (cm)
Length (x)	4.3	4.4
Width (y)	3.3	3.5
Height (z)	2.8	3

ⓐ (46.2 ± 6.77) cm^3 ⓑ (46.2 ± 0.15) cm^3 ⓒ (67.1 ± 0.2) cm^3 ⓓ (67.1 ± 7) cm^3

Solution

Clue

The volume of a cuboid is determined by multiplying (the length (x) × the width (y) × the height (z)), so the measurement process is indirect. The relative error and the absolute error in measuring the volume of the cuboid can be calculated as follows:

$$r = r_x + r_y + r_z \quad , \quad r_x = \frac{\Delta x}{x_o} \quad , \quad r_y = \frac{\Delta y}{y_o} \quad , \quad r_z = \frac{\Delta z}{z_o}$$

$$, \ \Delta V = r V_o \quad , \quad V_o = x_o y_o z_o$$

The relative error in measuring:

The length	The width	The height
$r_x = \frac{\lvert 4.4 - 4.3 \rvert}{4.4} = \frac{1}{44}$	$r_y = \frac{\lvert 3.5 - 3.3 \rvert}{3.5} = \frac{2}{35}$	$r_z = \frac{\lvert 3 - 2.8 \rvert}{3} = \frac{1}{15}$

The relative error in measuring the volume:

$$r = \frac{1}{44} + \frac{2}{35} + \frac{1}{15} = \frac{677}{4620}$$

The actual value of the volume:

$$V_o = 4.4 \times 3.5 \times 3 = 46.2\ cm^3$$

The absolute error in measuring the volume:

$$\Delta V = \frac{677}{4620} \times 46.2 = 6.77\ cm^3$$

$$V = V_o \pm \Delta V = (46.2 \pm 6.77)\ cm^3$$

∴ **The correct choice is ⓐ.**

What if you are asked to calculate the area of the largest face in the cuboid, **what** will be your answer?

Example 3

An object has a mass of (2000 ± 10) kg and a volume of (0.1 ± 0.001) m^3, so its density equals

(Knowing that: Density (ρ) = $\frac{\text{Mass (m)}}{\text{Volume (V)}}$)

ⓐ $(2 \times 10^4 \pm 10^4)\ kg/m^3$

ⓑ $(2 \times 10^4 \pm 300)\ kg/m^3$

ⓒ $(200 \pm 10)\ kg/m^3$

ⓓ $(200 \pm 30)\ kg/m^3$

Solution

The relative error in measuring the mass:

$$r_1 = \frac{\Delta m}{m_o} = \frac{10}{2000} = \frac{1}{200}$$

The relative error in measuring the volume:

$$r_2 = \frac{\Delta V}{V_o} = \frac{0.001}{0.1} = \frac{1}{100}$$

The relative error in measuring the density:

$$r = r_1 + r_2 = \frac{1}{200} + \frac{1}{100} = \frac{3}{200}$$

The actual value of the density:

$$\rho_o = \frac{m_o}{V_o} = \frac{2000}{0.1} = 2 \times 10^4\ kg/m^3$$

The absolute error in measuring the density:

$\Delta\rho = r\,\rho_o = \frac{3}{200} \times 2 \times 10^4 = 300\ kg/m^3$

$\rho = (\rho_o \pm \Delta\rho) = (2 \times 10^4 \pm 300)\ kg/m^3$

∴ **The correct choice is (b).**

Test yourself

Answered

1 **Choose the correct answer:** The mass of a solid cube was measured with 2 % of error and its side length was measured with 2 % of error, then the percentage of error in measuring the density of the cube material equals ....

(a) 1% (b) 2% (c) 8% (d) 10%

2 A body of mass (5 ± 0.5) kg is moving with speed (2 ± 0.2) m/s, **then calculate** the absolute error in measuring its kinetic energy.

(Knowing that: Kinetic energy of the body = $\frac{1}{2}mv^2$)

....

....

Chapter 1

Types of Measurement & Measurement Error

The questions signed by ✳ are answered in detail.

To watch videos of how to solve questions use the App

GPS

Interactive test

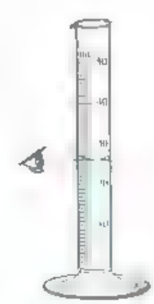
Multiple choice questions

Types of measurement and error in measurements

1. From the examples of a direct measurement, measuring the ....
   - (a) mass of a body by a balance
   - (b) area of a room by a meter tape
   - (c) volume of a cuboid by measuring the length, the width and the height
   - (d) density of a liquid by measuring its mass and its volume

2. From the examples of an indirect measurement, measuring the ....
   - (a) density of a liquid by a hydrometer
   - (b) height of a person by a meter tape
   - (c) mass of a body by a balance
   - (d) volume of a cube by measuring its length

3. The measurement process shown in the opposite figure is considered as a (an) .... measurement.

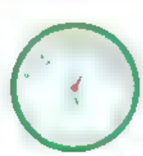


   - (a) complex
   - (b) complicated
   - (c) direct
   - (d) indirect

4. The opposite figure shows an ammeter when there is no electric current passing through it, then which of the following figures describes this ammeter when a current of intensity 3 A passes through it?

(a)

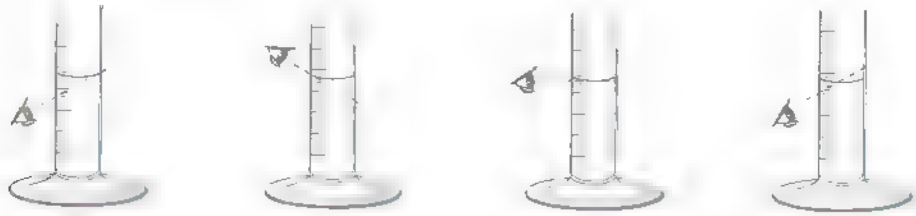
(b)



(c)

(d)

5 Which of the following procedures is the right procedure to measure the volume of the water in a graduated cylinder?



a b c d

6 When measuring the current intensity in an electric circuit, the intensity was expected to be 2.5 A, so which of the following ammeters is the most appropriate for measuring the current accurately?

(a) (b) (c) (d)

Estimating error of measurement

7 The best way to judge the accuracy of measurement is through ....

(a) the absolute error

(b) the relative error

(c) the product of the relative error and the absolute error

(d) dividing the relative error by the absolute error

8 A student measured the length of a wooden piece which is found to be 50.2 cm, while the actual value is 50 cm. Accordingly:

(i) The absolute error = ...

(a) 50 cm (b) 2 cm (c) 0.2 cm (d) 0.04 cm

(ii) The error percentage = ...

(a) 10 % (b) 2 % (c) 50 % (d) 0.4 %

9 The relative error in measuring the area of a room is 0.06 where the actual value of the area is 30 m^2, then the absolute error in measuring this area is ....

(a) 1.8 m^2 (b) 0.002 m^2 (c) 0.06 m^2 (d) 1.2 m^2

10 A student measured the length of a passage by using a meter tape, he found that the length equals (10 ± 0.1) m, then ....

	Absolute error	Relative error
ⓐ	10 m	0.01
ⓑ	0.1 m	0.01
ⓒ	0.1 m	0.001
ⓓ	10 m	0.001

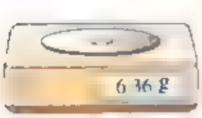
11 ✳ An engineer measured the height of a building which was found to be 55.2 m. If there was an error of 0.02 m in this measurement, so the real value of the building height is between ...., ...

ⓐ 55.4 m, 55.6 m
ⓑ 55.18 m, 55.22 m
ⓒ 55.19 m, 55.21 m
ⓓ 55.16 m, 55.24 m

12 ✳ A student measures some physical quantities in his room and he gets the following results, so which of them is more accurate?

	The physical quantity	Its value
ⓐ	The room length	(6 ± 0.05) m
ⓑ	The room width	(4 ± 0.05) m
ⓒ	The room ceiling height	(3.5 ± 0.05) m
ⓓ	The room temperature	(30 ± 0.5) °C

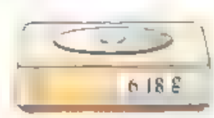
13 A golden ring of mass 6.21 g is placed on several sensitive balances to get different readings as in the following figures, which one of them is the most accurate?



ⓐ

ⓑ

ⓒ



ⓓ

14 ✳ The solar year is approximately equal to $\pi \times 10^7$ s, then the percentage of error in this approximation equals .... (Knowing that: The solar year = 365.25 days)

ⓐ 0.2 %
ⓑ 0.4 %
ⓒ 2 %
ⓓ 4 %

15 ✳ If x = (1 ± 0.01) kg and y = (50 ± 1) g, then (x + y) equals ....

ⓐ (1050 ± 1.01) g
ⓑ (1.05 ± 1.01) kg
ⓒ (50.1 ± 1.01) g
ⓓ (1.05 ± 0.011) kg

16 ✳ If rod A has a length of (2.35 ± 0.01) cm and rod B has a length of (5.68 ± 0.01) cm, then rod B is longer than rod A by ....

ⓐ (3.33 ± 0.00) cm
ⓑ (3.33 ± 0.02) cm
ⓒ (2.43 ± 0.01) cm
ⓓ (2.43 ± 0.001) cm

17 ✳ If the mass of a body is (10 ± 1) kg and its velocity is (4 ± 0.04) m/s, then its momentum (P_L) equals .... (Knowing that: Momentum = Mass × Velocity)

ⓐ (1.6 ± 1.4) kg.m/s
ⓑ (40 ± 1.04) kg.m/s
ⓒ (40 ± 4.4) kg.m/s
ⓓ (40 ± 0.04) kg.m/s

18 ✳ On determining the density of a liquid, the mass of a volume of it was measured and it was (400 ± 0.2) kg and its volume was (0.5 ± 0.01) m^3, then the absolute error and the relative error in measuring the density of the liquid are ....

(Knowing that: Density $= \frac{\text{Mass}}{\text{Volume}}$)

ⓐ 0.025, 15.6 kg/m^3
ⓑ 0.0205, 0.2 kg/m^3
ⓒ 0.025, 20 kg/m^3
ⓓ 0.0205, 16.4 kg/m^3

19 ✳ If $x = (5 \pm 0.1)$ cm and $y = (10 \pm 0.2)$ cm, then:

(i) $x + y$ equals ....

ⓐ (15 ± 0.3) cm
ⓑ (15 ± 0.1) cm
ⓒ (5 ± 0.3) cm
ⓓ (5 ± 0.1) cm

(ii) $2x + y$ equals ....

ⓐ (30 ± 0.4) cm
ⓑ (20 ± 0.4) cm
ⓒ (30 ± 0.3) cm
ⓓ (20 ± 0.3) cm

(iii) xy equals ....

ⓐ (50 ± 2.5) cm^2
ⓑ (50 ± 1) cm^2
ⓒ (50 ± 2) cm^2
ⓓ (25 ± 2) cm^2

(iv) xy^2 equals ....

ⓐ (50 ± 3) cm^3
ⓑ (500 ± 20) cm^3
ⓒ (500 ± 10) cm^3
ⓓ (500 ± 30) cm^3

20 ✳ The opposite table shows the real value and the measured value of the dimensions of a metallic cylinder, then:

(Knowing that:
The volume of the cylinder
= Area of the base × The height)

The dimension	The measured value (cm)	The real value (cm)
The radius of the cylinder base	2.2	2.3
The height of the cylinder	4.6	4.8

(i) The relative error in measuring the volume of the cylinder equals ……

(a) $\frac{17}{138}$ (b) $\frac{3}{22}$ (c) $\frac{71}{552}$ (d) $\frac{47}{552}$

(ii) The absolute error in measuring the volume of the cylinder equals ……

(a) $6.79\ cm^3$ (b) $9.83\ cm^3$ (c) $10.26\ cm^3$ (d) $10.88\ cm^3$

21 ✳ The percentage of error in measuring the side length of a cube is 1%, then the relative error in measuring its volume is ………..

(a) 0.01 (b) 0.02 (c) 0.03 (d) 0.04

22 ✳ The percentage of error in measuring the mass of a cube is 1.5 % and the percentage of error in measuring the length of its side is 1%, so the percentage of error in measuring the density of the cube material equals …… (Knowing that: Density = $\frac{\text{Mass}}{\text{Volume}}$)

(a) 1.5 % (b) 2.5 % (c) 3 % (d) 4.5 %

Essay questions

1 State the precautions considered when using:

(1) The metric ruler to measure the length of an object.

(2) The sensitive balance.

2 **Explain the following sentences:**

(1) The value of absolute error is always positive.

(2) The relative error has no measuring unit.

(3) The relative error is a better indicator for measurement accuracy than the absolute error.

3 When students were measuring the mass of a piece of iron in the Physics lab, the teacher asked them to repeat the measuring process several times and calculate the average. **What** is the purpose of the teacher's demand?

4 Four friends were measuring four different physical quantities and their results were as follows:

(a) (10 ± 0.1) cm (b) (1 ± 0.01) m

(c) (50 ± 0.5) kg (d) (200 ± 0.02) s

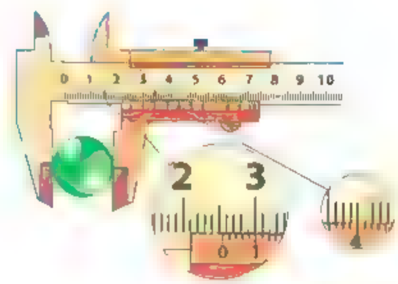
Arrange these measurements in ascending order according to their accuracy.

Questions that measure high levels of thinking

Answered in detail

Choose the correct answer :

1 The vernier caliper was used to measure the diameter of a metallic ball as shown in the opposite figure, then:



(i) The measured value equals ....

ⓐ 2.54 cm ⓑ 2.45 cm

ⓒ 2.46 cm ⓓ 2.64 cm

(ii) If the real value of the diameter of the ball is 2.53 cm, so the absolute error and the percentage of error are ....

ⓐ 0.11 cm, 4.3 % ⓑ 0.01 cm, 0.4 % ⓒ 0.11 cm, 2.8 % ⓓ 0.01 cm, 3.2 %

2 If the radius of a solid sphere is (6.5 ± 0.2) cm and its mass equals (1.85 ± 0.02) kg, then the density of the sphere material approximately equals ....

(Knowing that: Density $= \frac{\text{Mass}}{\text{Volume}}$)

ⓐ $(1.61 \pm 0.17) \times 10^3$ kg/m^3

ⓑ $(1.61 \pm 0.1) \times 10^3$ kg/m^3

ⓒ $(1.61 \pm 0.02) \times 10^{-3}$ kg/m^3

ⓓ (6.79 ± 0.07) kg/m^3

Test on Chapter 1

Physical Measurements

First — Choose the correct answer

1. The suitable method for measuring the thickness of a thin sheet accurately is ....

(a)

(b)

(c)

(d)

2. The mass of a cube and the length of one of its sides were measured, where the relative error in measuring its mass was 2 % and the relative error in measuring its side length was 1.5 %, then the relative error in measuring its density is ....

(Knowing that: Density = $\frac{\text{Mass}}{\text{Volume}}$)

(a) 0.5 %   (b) 3.5 %   (c) 6.5 %   (d) 9.5 %

3. If the radius of a particle is 5.1 nm, then the diameter of the particle equals ....

(a) 10.2×10^{-3} µm   (b) 1.02×10^{-7} mm

(c) 10.2×10^{-8} m   (d) all the previous

4. If the dimensional formula of a physical quantity is $M^x L^x T^{x-3}$ where x is an integer number, by using the opposite table this quantity may be the ....

(a) force   (b) acceleration

(c) work   (d) velocity

The physical quantity	The measuring unit
Force	$kg.m/s^2$
Acceleration	m/s^2
Work	$kg.m^2/s^2$
Velocity	m/s

5. An empty large box of mass (20 ± 0.01) kg, when a man sits inside the box, the mass of the box and the man together becomes (0.1 ± 0.001) ton, so the mass of the man is ....

(a) (120 ± 0.009) kg   (b) (120 ± 0.011) kg

(c) (80 ± 1.01) kg   (d) (80 ± 0.99) kg

6. If the dimensional formula of a physical quantity is $M L T^{-1}$, then its measuring unit is ....

(a) kg.m.s   (b) $kg.m.s^{-1}$ (c) $kg.m^{-1}.s^{-1}$ (d) $kg.m^{-1}.s$

7. How many bottles of volume 1000 cm^3 are needed to fill a tank of capacity 1 m^3?

ⓐ 1 ⓑ 10 ⓒ 1000 ⓓ 100

8. If the dimensions of quantity x are $M^0 L^0 T$ and the dimensions of quantity y are MLT^{-1}, then the dimensions MLT^{-2} describe the quantity ....

ⓐ $x\,y$ ⓑ $x\,y^2$ ⓒ $\frac{x}{y}$ ⓓ $\frac{y}{x}$

9. The length of a rectangle was measured to be (6 ± 0.01) cm and its width was measured to be (4 ± 0.01) cm, then the percentage of error in measuring the perimeter of the rectangle is ....

ⓐ 0.2 % ⓑ 0.4 % ⓒ 0.8 % ⓓ 2 %

10. If the dimensions of A are L^2T and the dimensions of B are LT^2, then the dimensions of the quantity A – 3 B are ....

ⓐ L^3T^3 ⓑ LT ⓒ L^2T^2 ⓓ not defined

11. Which of the following lengths is larger?

ⓐ 10^{-2} mm ⓑ 1 µm ⓒ 10^4 nm ⓓ 10^{-6} Gm

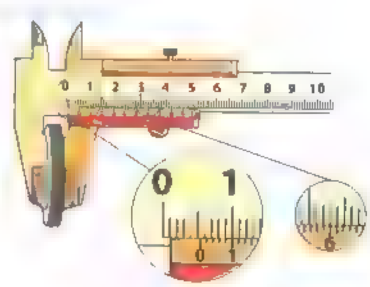
12. Given that: (F) is the force, (m) is the mass, (a) is the acceleration, $[F] = MLT^{-2}$ and $[a] = LT^{-2}$, which of the following equations might be correct?

ⓐ $F = \frac{m}{a}$ ⓑ $F = ma^2$ ⓒ $F = \frac{a}{m}$ ⓓ $F = ma$

13. If the equation $(d = xv + \frac{1}{2} a y^2)$ describes the motion of a body, where the dimensions of the quantities d, v and a are L, LT^{-1} and LT^{-2} respectively, the dimensions of both x and y are ....

	Dimensions of x	Dimensions of y
ⓐ	T	T
ⓑ	T	T^2
ⓒ	T^{-1}	T
ⓓ	T^{-1}	T^2

14. The opposite figure shows a vernier caliper being used to measure the thickness of a metallic coin, then the measured value of the coin thickness is ....



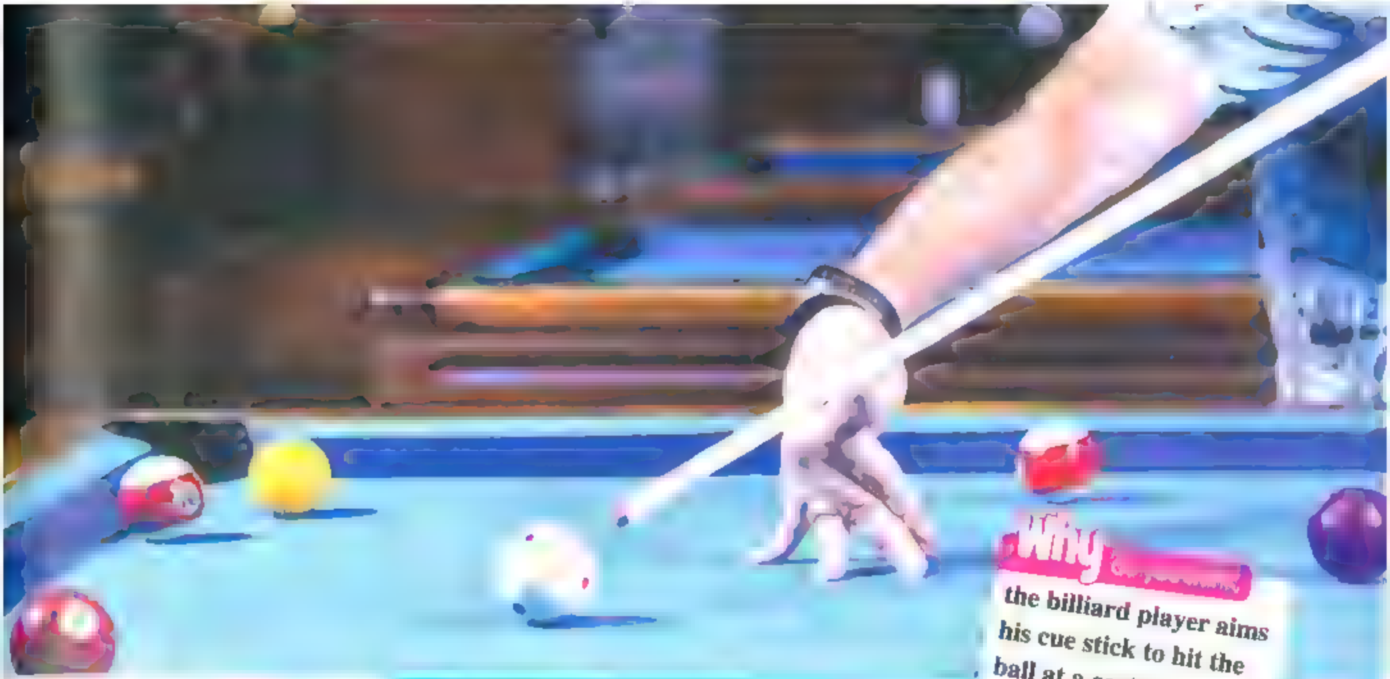
ⓐ 5.6 cm ⓑ 1.6 cm
ⓒ 5.6 mm ⓓ 1.6 mm

Second Answer the following questions

15 **Why** is not the glass used in manufacturing a standard meter?

16 "The absolute error is the best indicator for measurement accuracy"

Discuss the validity of the previous sentence.



Chapter 2 Scalar and Vector Quantities

When measuring a physical quantity like:

Temperature

- When we say that the temperature of the human body is 37°C, then this is enough to describe the temperature fully, because we mentioned its magnitude and its measuring unit, so the temperature is considered a scalar quantity.

Velocity

- When an aircraft radar detects that the velocity of a target is 40 km/h, then this isn't enough to deal with the target because we mentioned its magnitude and its measuring unit but we didn't mention its direction, therefore the velocity is considered a vector quantity.

Accordingly, physical quantities can be classified into:

1 Scalar quantities

- It is a physical quantity that can be fully defined by its **magnitude only** and it has no direction, such as:
  - Distance.
  - Mass.
  - Time.
  - Temperature.
  - Energy.

2 Vector quantities

- It is a physical quantity that can be fully defined by **both magnitude and direction**, such as:
  - Displacement.
  - Velocity.
  - Acceleration.
  - Force.

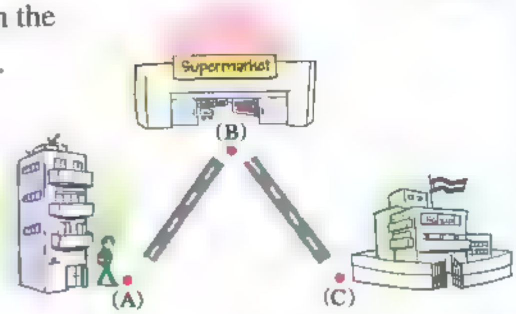
Distance and Displacement

EKB

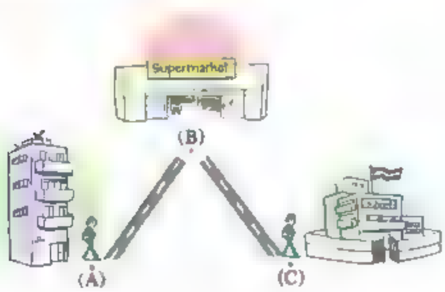
⊙ To illustrate the difference between scalar and vector quantities, we will investigate the difference between the concept of displacement and the concept of distance.

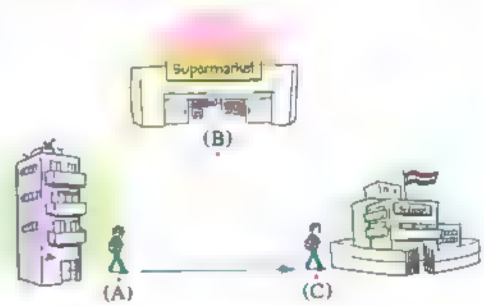
This can be clarified through the next example:

The opposite figure shows a student who starts his motion from the home (**point A**) till he reaches the school (**point C**) passing by the supermarket (**point B**), then:



Distance (s)	Displacement (d)
Is represented by	
▶ The length of the path ($\overline{AB} + \overline{BC}$) which is covered by the student from the home (A) to the school (C) passing by the supermarket (B).	▶ The length of the straight line $\overline{AC}$ from the home (A) to the school (C) directly and the direction of the arrow from (A) to (C) directly.





Which means

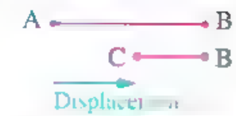
Distance	Displacement
▶ Is the length of the path moved by an object from a position to another.	▶ Is given by the length of the straight line segment (shortest distance) in a given direction between the starting point of motion and the end point.
▶ Is **a scalar quantity** because it can be fully defined by its magnitude only and it has no direction.	▶ Is **a vector quantity** because it can be fully defined by both its magnitude and direction together.
▶ It is always positive.	▶ It may be positive, negative or zero.

From the previous, we can conclude that:

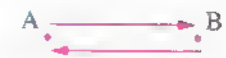
If a body moves in one dimension (straight line)

- **In one constant direction** → From point A to point B, then the magnitude of the displacement (d) equals the covered distance (s).

- **In two opposite directions (one is considered positive and the other is negative)**
  - And doesn't return to its starting point, then
    - The covered distance: $s = \overline{AB} + \overline{BC}$
    - The magnitude of displacement: $d = \overline{AB} - \overline{BC}$

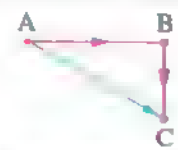


  - And returns to its starting point, then
    - The covered distance: $s = 2\,\overline{AB}$
    - The displacement: $d = 0$



If a body

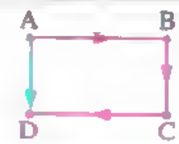
- **In straight paths**



$s = \overline{AB} + \overline{BC}$

$d = \overrightarrow{AC}$

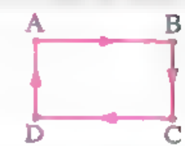
In the direction from A to C



$s = \overline{AB} + \overline{BC} + \overline{CD}$

$d = \overrightarrow{AD}$

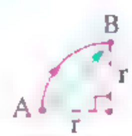
In the direction from A to D



$s = \overline{AB} + \overline{BC} + \overline{CD} + \overline{DA}$

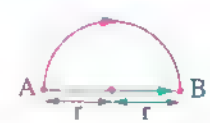
$d = 0$

- **In curved paths like a body that moves on a circle**



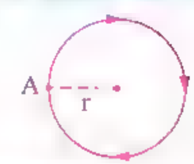
$s = \frac{1}{2}\pi r$

$d = \sqrt{2}\,r$



$s = \pi r$

$d = 2r$



$s = 2\pi r$

$d = 0$

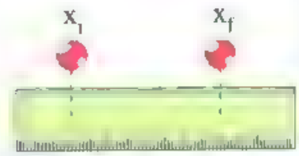
Integration with Mathematics

You can revise Pythagorean theorem from section (3) page (10).

Notes :

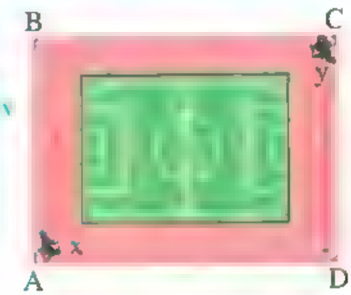
(1) **The magnitude of the displacement is less than or equal to the covered distance** because the magnitude of the displacement is the shortest straight distance between the starting point of motion and the end point of motion.

(2) If a body moves from position x_i to position x_f as in the opposite figure, then the displacement of the body is calculated from the relation: $d = x_f - x_i$



Example 1

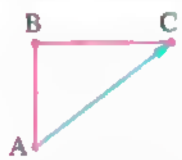
The opposite figure represents a rectangular racetrack around a playground where two players x, y are racing. Player x takes path ABC and player y takes path CDA, so when the two players finish the race they will have ....



ⓐ equal displacements and will cover equal distances
ⓑ different displacements and will cover equal distances
ⓒ equal displacements and will cover different distances
ⓓ different displacements and will cover different distances

Solution

Player x



$s_x = AB + BC$

$d_x = AC$

In the direction from A to C

Player y

$s_y = CD + DA$

$d_y = CA$

In the direction from C to A

$\because$ The playground has a rectangular shape.

$\therefore AB = CD \quad , \quad BC = DA \qquad \therefore s_x = s_y$

$\therefore$ **The two players cover equal distances.**

$\because$ The directions of the displacements are different.

$\therefore$ **The two players have different displacements.**

$\therefore$ **The correct choice is ⓑ.**

What if the two players x, y race through the paths ABC, ADC respectively, so when they finish the race **will** they have equal displacements **and will** they cover equal distances?

Example 2

An athlete has moved to west through a displacement of (50 m), then stopped for a moment and moved back to east through a displacement of (30 m), then:

(i) The covered distance by the athlete equals ....

ⓐ 20 m ⓑ 30 m ⓒ 50 m ⓓ 80 m

(ii) The displacement of the athlete equals ....

ⓐ 20 m to the west direction ⓑ 20 m to the east direction
ⓒ 80 m to the west direction ⓓ 80 m to the east direction

Solution

(i) s = 50 + 30 = 80 m

∴ **The correct choice is ⓓ.**

(ii) Assume that the west direction is the positive direction of motion.

d = + 50 – 30 = + 20 m

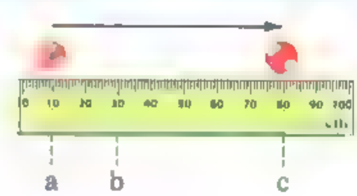
∴ The displacement of the athlete is 20 m to the west direction.

∴ **The correct choice is ⓐ.**

What if the athlete returns to its starting point of motion, **what** will be the magnitude of his displacement and the covered distance by him?

Example 3

The opposite figure represents the motion of a ball along a graduated ruler. If we considered that the right direction is the positive direction of motion and the ball moved:

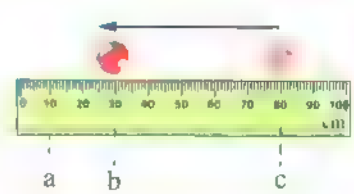


(i) from a to c, so its displacement is ....

ⓐ 20 cm ⓑ 50 cm
ⓒ 70 cm ⓓ 80 cm

(ii) from c to b, so its displacement from point c is ....

ⓐ 50 cm ⓑ – 50 cm
ⓒ 70 cm ⓓ – 70 cm



Solution

(i) $d = x_f - x_i = 80 - 10 = 70$ cm

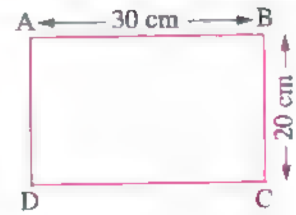
∴ **The correct choice is ⓒ.**

(ii) $d = x_f - x_i = 30 - 80 = -50$ cm

∴ **The correct choice is ⓑ.**

Example 4

In the opposite figure a rectangle (ABCD) has length 30 cm and width 20 cm. Find the distance and the displacement covered by an object moving along its perimeter as the following cases:



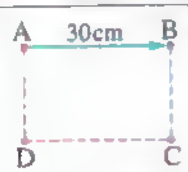
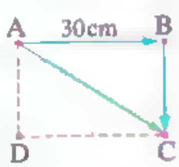
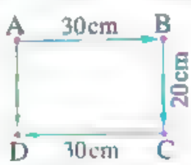
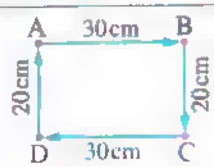
(a) The object moves from (A) to (B).

(b) The object moves from (A) to (C) passing by point (B).

(c) The object moves from (A) to (D) passing by points (B) and (C).

(d) The object moves from (A) passing by points (B), (C) and (D) returning back to (A).

Solution

	Path of object	Distance (s)	Displacement (d)
(a)		s = AB = **30 cm**	d = AB = **30 cm** **In the direction of $\overrightarrow{AB}$**
(b)		s = AB + BC = 30 + 20 = **50 cm**	$d = \sqrt{(AB)^2 + (BC)^2}$ $= \sqrt{(30)^2 + (20)^2}$ = **36.06 cm** **In the direction of $\overrightarrow{AC}$**
(c)		s = AB + BC + CD = 30 + 20 + 30 = **80 cm**	d = **AD = 20 cm** **In the direction of $\overrightarrow{AD}$**
(d)		s = AB + BC + CD + DA = 30 + 20 + 30 + 20 = **100 cm**	d = **zero**

Example 5

An object moves in anticlockwise direction on a circle of radius 2 cm and center c. Find the distance and the magnitude of the displacement covered by the object when it moves:

(a) $\frac{1}{4}$ revolution.

(b) $\frac{1}{2}$ revolution.

(c) $\frac{3}{4}$ revolution.

(d) a complete revolution.

Solution

	Path of object	Distance (s)	Magnitude of displacement (d)
(a)		$s = \frac{1}{4}(2\pi r)$ $= \frac{1}{4} \times 2 \times \frac{22}{7} \times 2 = \frac{22}{7}$ cm	From Pythagorean theorem: $d = \sqrt{r^2 + r^2}$ $= \sqrt{2}\, r = 2\sqrt{2}$ cm
(b)		$s = \frac{1}{2}(2\pi r)$ $= \frac{1}{2} \times 2 \times \frac{22}{7} \times 2 = \frac{44}{7}$ cm	$d = 2r = 2 \times 2 = 4$ cm
(c)		$s = \frac{3}{4}(2\pi r)$ $= \frac{3}{4} \times 2 \times \frac{22}{7} \times 2 = \frac{66}{7}$ cm	From Pythagorean theorem: $d = \sqrt{(r)^2 + (r)^2} = \sqrt{2}\, r = 2\sqrt{2}$ cm
(d)		$s = 2\pi r$ $= 2 \times \frac{22}{7} \times 2 = \frac{88}{7}$ cm	d = zero, because the body returns to its starting point.

What if the distance covered by the body is 44 cm, **what** will be the number of revolutions completed by the body?

From the previous example, we conclude that when a body moves in a circular path:

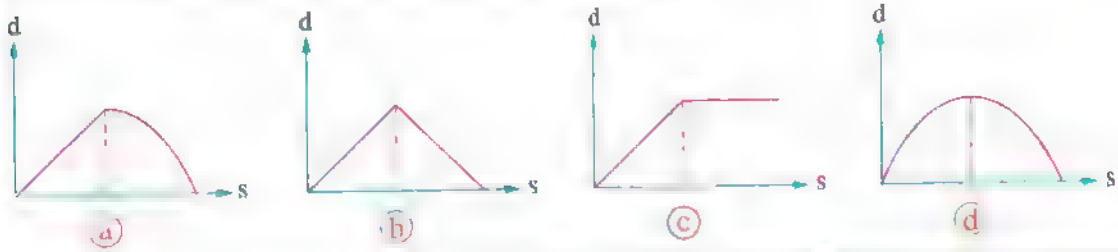
1. The magnitude of its displacement when it moves $\frac{1}{4}$ revolution
   = The magnitude of its displacement when it moves $\frac{3}{4}$ revolution
2. Its displacement when it moves $\frac{1}{4}$ revolution ≠ Its displacement when it moves $\frac{3}{4}$ revolution, because the direction of the displacement when the body moves $\frac{1}{4}$ revolution is different from the direction of the displacement when it moves $\frac{3}{4}$ revolution.

Test yourself

Answered

Choose the correct answer:

The opposite figure represents the path of a body that moves from point A to point B then it moves in a circular path of center A to complete one revolution, so which of the following graphs represents the relation between the magnitude of displacement (d) of the body from point A and the covered distance (s) by it?



Representation of vector quantities

- The vector quantity (such as force or displacement) is represented by a directed straight segment (⟶) whose base is at the starting point and its tip is at the end point where:
  - Its length is proportional to the vector **magnitude**.
  - The arrow direction points to the **direction** of the vector quantity.
  - The vector quantity is denoted by a bold letter (**A**) or a letter tagged by a small arrow that always points to the right ($\overrightarrow{A}$).

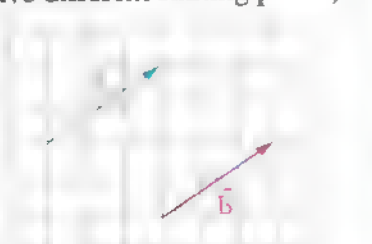
EKB

Some basics of vector algebra

1 Equality of vectors

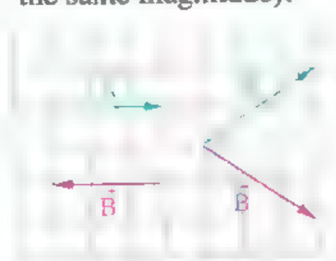
Two vectors are equal ($\overrightarrow{A} = \overrightarrow{B}$) when they have:

- The same magnitude.
- The same direction (even if they have different starting points).



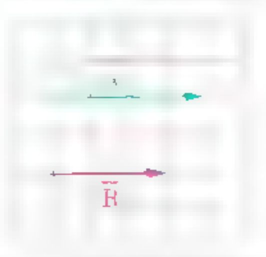
Two vectors are not equal ($\overrightarrow{A} \neq \overrightarrow{B}$) when they have:

- Different directions (even if they have the same magnitude).



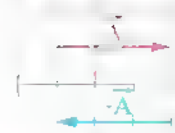
Or

- Different magnitudes (even if they have the same direction).



2 Negative vector

• Vector $-\vec{A}$ has the same magnitude of vector $\vec{A}$ but in the opposite direction.



The product of a constant magnitude by a vector

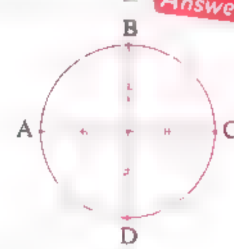
• Vector $2\vec{A}$ is a vector that has double the magnitude of vector $\vec{A}$ and has the same direction, while vector $-2\vec{A}$ is a vector that has double the magnitude of vector $\vec{A}$ and its direction is in the opposite direction of vector $\vec{A}$.

Test yourself

Answered

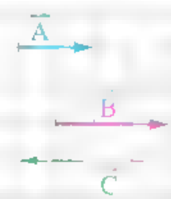
Choose the correct answer:

1 Two bodies move on the circle shown in the opposite figure, then the displacements of the bodies become equal and also the distances covered by them when ....



	The path of the first body	The path of the second body
(a)	ABC	BCD
(b)	BC	AD
(c)	BCD	DAB
(d)	DC	DA

2 The opposite figure represents three vectors, so vector $\vec{A}$ equals ....



(a) $2\vec{B}$ (b) $-\frac{1}{2}\vec{B}$

(c) $2\vec{C}$ (d) $-\frac{1}{2}\vec{C}$

Vector algebra

⊙ The mathematical operations are performed on the vector quantities in a different way from that on the scalar quantities and this type of operations is called vector algebra.

Vector algebra

- **Addition and subtraction of vectors**
- **Resolution of a vector**
- **Product of vectors**
  1. Scalar (dot) product
  2. Cross product

First Addition and subtraction of vectors

⊙ Two vectors can be added (finding the resultant of two vectors) by two methods:

First method

If there is an angle between them θ where (0° < θ < 180°), then their resultant can be found by drawing a parallelogram as follows:

(a) Move one of the two vectors without changing its direction or magnitude, to make the two vectors have the same starting point.

(b) Draw two sides that are parallel to the vectors $\vec{A}$ and $\vec{B}$ to complete the shape of parallelogram where the diagonal represents the resultant vector $\vec{C}$ that has a direction from the starting point of the two vectors to point E.

Second method

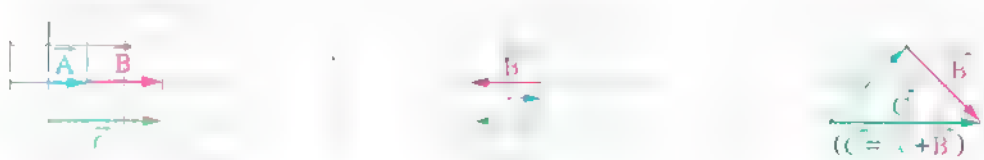
⊙ **If there is an angle between them θ where:**

$\theta = 0°$ (They are in the same direction)	$\theta = 180°$ (They are in two opposite directions)	$0° < \theta < 180°$

Their resultant can be found as follows

(a) Move one of the two vectors without changing its direction or magnitude to make the end point of one of them be at the starting point of the other.

(b) Join the starting point of vector $\vec{A}$ with the end point of vector $\vec{B}$, so the vector $\vec{C}$ will represent the resultant (net) vector which has a direction from the starting point of $\vec{A}$ to the end point of $\vec{B}$.



Enrichment information

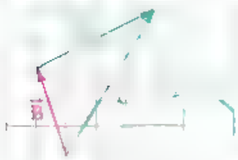
- The magnitude of the resultant of two vectors $\vec{A}$ and $\vec{B}$ that has angle θ between them is calculated from the relation: $C^2 = A^2 + B^2 + 2\,AB\cos\theta$

If the angle between the two vectors

$\theta = 0°$	$\theta = 90°$	$\theta = 180°$
$C = A + B$	$C = \sqrt{A^2 + B^2}$	$C = A - B$

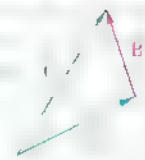
Note :

- The addition of vectors is characterized by commutative property where :
  $\vec{A} + \vec{B} = \vec{B} + \vec{A} = \vec{C}$



The starting point of vector $\vec{A}$ is at the end point of vector $\vec{B}$

The starting point of vector $\vec{B}$ is at the end point of vector $\vec{A}$



Subtraction of two vectors

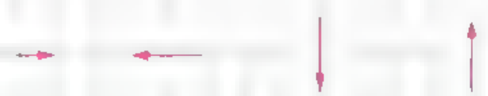
- Subtracting the two vectors $\vec{A}$ and $\vec{B}$ is equivalent to the addition of the two vectors $\vec{A}$ and $-\vec{B}$ as shown in the opposite figure.

Test yourself

Answered

Choose the correct answer:

In the opposite figure, there are two vectors $\vec{A}$ and $\vec{B}$. So, which of the following choices represents the resultant $\vec{C}$ for the two vectors?



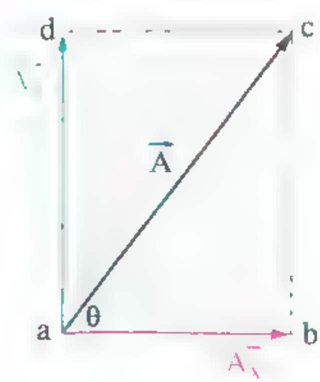
ⓐ ⓑ ⓒ ⓓ

Finding the resultant (net) of two perpendicular vectors

The resultant of two perpendicular vectors of the same kind $\vec{A_x}$ and $\vec{A_y}$ is found by two methods:

1 Graphically:

1. Draw a horizontal line (ab) on the graph paper to represent the first vector $(\vec{A_x})$.
2. Perpendicular to (ab) at the point (a), draw a vertical line (ad) to represent the second vector $(\vec{A_y})$.
3. Complete the rectangle abcd.
4. Join the diagonal (ac) to represent the magnitude and the direction of the resultant $(\vec{A})$.



5. Measure the length of the line segment (ac) that represents the magnitude of the resultant ($\overrightarrow{A}$).
6. By using the protractor, measure the angle θ ($b\hat{a}c$) that defines the direction of the resultant vector relative to the first vector ($\overrightarrow{A_x}$).

2 Theoretically:

1. Find the magnitude of the resultant using Pythagorean theorem for the right angled triangle: $(ac)^2 = (ab)^2 + (bc)^2$

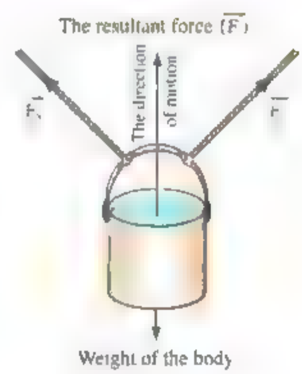
$$\therefore A^2 = A_x^2 + A_y^2 \quad , \quad A = \sqrt{A_x^2 + A_y^2}$$

2. We can find the angle (θ) that is made by the resultant vector with the direction of the first vector by the relation:

$$\tan\theta = \frac{\text{Opposite}}{\text{Adjacent}} = \frac{A_y}{A_x}$$

Application of the resultant force

- When two forces or more act on an object (as in the opposite figure), this object will move in a certain direction determined by the resultant of the forces acting on the object which is called the **resultant (net) force** ($\overrightarrow{F}$) which is defined as follows:



Resultant force ($\overrightarrow{F}$):

It is a single force that produces the same effect on an object as that produced by the original acting forces.

Application

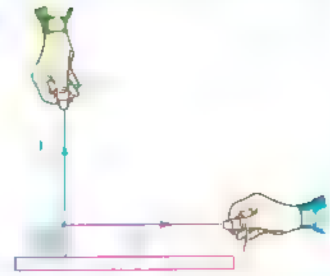
- If two forces of magnitudes **300 N** and **400 N** act on a car in the same direction, the car will move a certain distance during a certain time.

- If the two forces are replaced by a force of magnitude **700 N**, the car will move the same distance during the same time as in the first case when it was affected by the two forces (300 N, 400 N).

This means that: The **700 N** force makes the same effect on the car in the shown direction as the two forces **300 N**, **400 N** in the shown direction, therefore it is the resultant (net) of these two forces

Example

If there are two forces; one of them acts in the positive direction of x-axis with a magnitude of 4 N, while the other acts in the positive direction of y-axis with a magnitude of 3 N as shown in the figure, then:



(i) The magnitude of their resultant equals ....

ⓐ 1 N ⓑ 3 N

ⓒ 5 N ⓓ 7 N

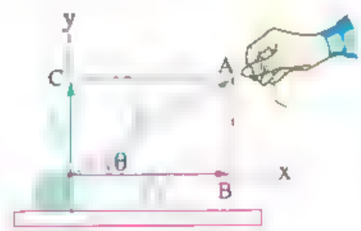
(ii) The angle made by the resultant force with the positive direction of x-axis equals ....

ⓐ 80.91° ⓑ 62.23° ⓒ 54.13° ⓓ 36.87°

Solution

(i) Complete the shape of parallelogram. A rectangle is obtained since the two forces are perpendicular to each other. Thus, the diagonal represents the resultant $\vec{F}$ as shown.

Applying Pythagorean theorem: $F^2 = F_x^2 + F_y^2$



$F = \sqrt{F_x^2 + F_y^2} = \sqrt{(4)^2 + (3)^2} = \sqrt{25} = 5$ N

∴ **The correct choice is ⓒ.**

(ii) $\tan\theta = \frac{F_y}{F_x} = \frac{3}{4}$

$\theta = 36.87°$

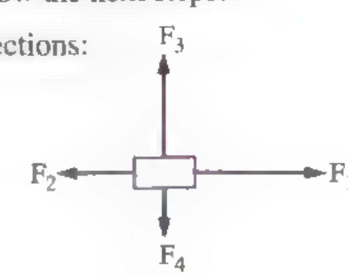
∴ **The correct choice is ⓓ.**

What if the direction of the force $\vec{F_y}$ is reversed, will the magnitude of the resultant of the two forces $\vec{F_x}$ and $\vec{F_y}$ change?

Guidline

- To find the resultant of several vectors (such as forces), we follow the next steps:

(1) Calculate the resultant in the horizontal and the vertical directions:

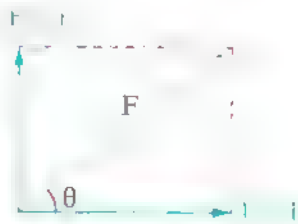


$F_x = F_1 - F_2$

$F_y = F_3 - F_4$

(2) Calculate the magnitude of the resultant force (F) of the two forces F_x, F_y:

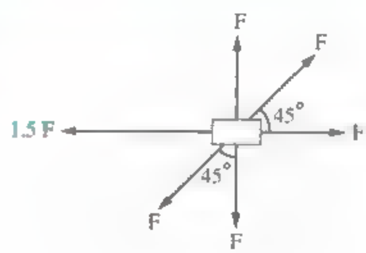
$$F = \sqrt{F_x^2 + F_y^2}$$

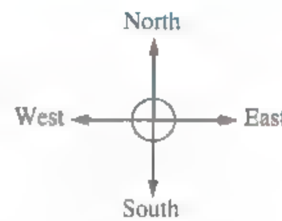


(3) Calculate the angle between the resultant force (F) and the horizontal: $\tan\theta = \dfrac{F_y}{F_x}$

Example

The opposite figure represents a body affected by multiple forces, so the net force that acts on the body is ....





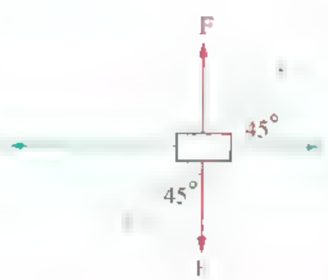
ⓐ F in the north direction

ⓑ 2 F in the west direction

ⓒ 0.5 F in the north direction

ⓓ 0.5 F in the west direction

Solution



- The two forces that are shown in red color are equal in magnitude and opposite in direction, so their resultant = zero
- The two forces that are shown in green color are also equal in magnitude and opposite in direction, so their resultant = zero
- The two forces that are shown in blue color are not equal in magnitude and they are opposite in direction where their resultant:

$F_t = 1.5\ F - F = 0.5\ F$ in the direction of the larger force in magnitude towards **the west**.

∴ **The correct choice is ⓓ.**

What if the force that acts in the north direction is 1.5 F, what will be the magnitude of the net force that acts on the body?

4 Test yourself

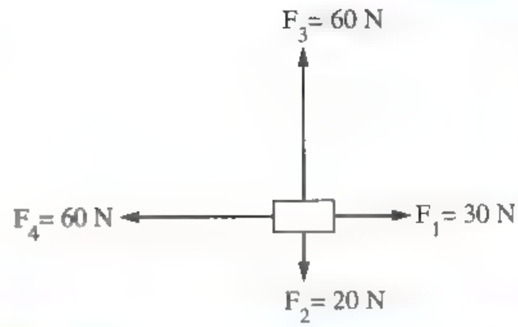
Answered

Choose the correct answer:

The opposite figure represents a body being affected by four forces, so the magnitude of the net force on the body is ....

ⓐ 170 N ⓑ 90 N

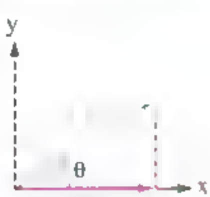
ⓒ 80 N ⓓ 50 N



Second Resolution of a vector

- Resolution of a vector is the reverse operation of getting the resultant of perpendicular vectors where a force (F) that makes an angle (θ) with x-axis can be resolved into two perpendicular components:

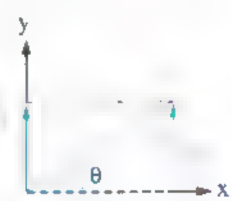
1 (F_x) is the force component in x-axis (horizontal component)



$$\cos\theta = \frac{\text{Adjacent}}{\text{Hypotenuse}} = \frac{F_x}{F}$$

$$F_x = F\cos\theta$$

2 (F_y) is the force component in y-axis (vertical component)



$$\sin\theta = \frac{\text{Opposite}}{\text{Hypotenuse}} = \frac{F_y}{F}$$

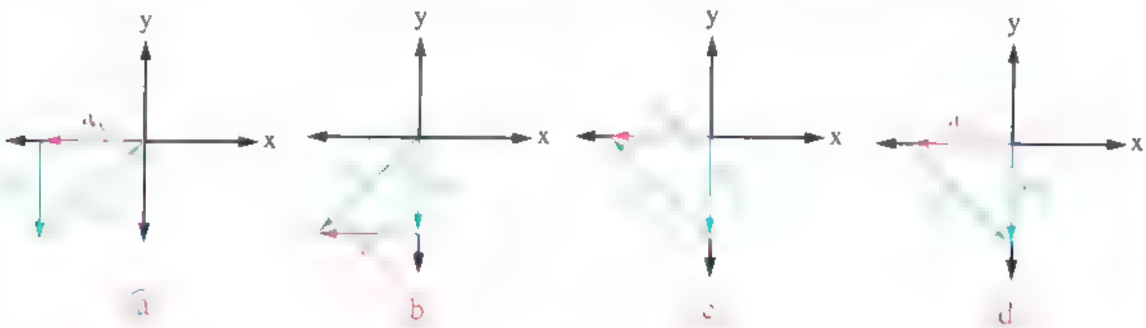
$$F_y = F\sin\theta$$

5 Test yourself

Answered

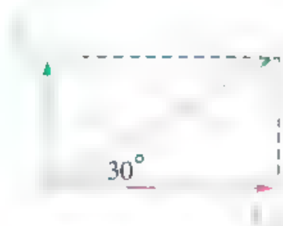
Choose the correct answer:

Which of the following figures represents correctly the resolution of vector $\vec{a}$?



Example 1

In the opposite figure, when resolving force $\vec{F}$ to its vertical component (F_y) and horizontal component (F_x), then the ratio $\left(\frac{F_x}{F_y}\right)$ is ..



ⓐ greater than one ⓑ less than one

ⓒ equal to one ⓓ can't determine the answer

Solution

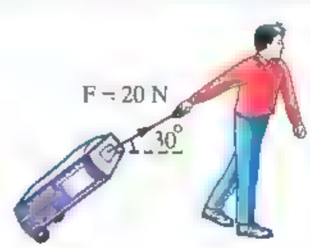
$F_x = F \cos \theta = F \cos 30$, $F_y = F \sin \theta = F \sin 30$

$\frac{F_x}{F_y} = \frac{\cos 30}{\sin 30} = 1.73$

∴ **The correct choice is ⓐ.**

Example 2

A man pulls a bag by a force of 20 N in a direction that makes an angle 30° with the horizontal as in the opposite figure, then:



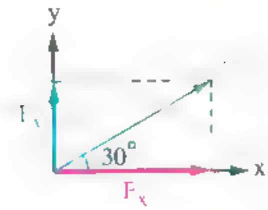
(i) The component of the force in the x-direction equals ....

ⓐ 10 N ⓑ 12.4 N ⓒ 17.3 N ⓓ 20.8 N

(ii) The component of the force in the y-direction equals ....

ⓐ 5 N ⓑ 10 N ⓒ 17.3 N ⓓ 20 N

Solution



(i) $F_x = F \cos \theta = 20 \cos 30° = 17.3$ N

∴ **The correct choice is ⓒ.**

(ii) $F_y = F \sin \theta = 20 \sin 30° = 10$ N

∴ **The correct choice is ⓑ.**

What if the angle between the force and the horizontal increases to be 45°, **which** component will have the greatest magnitude?

6 Test yourself

Answered

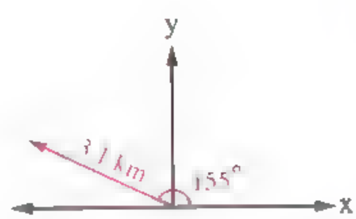
1 Choose the correct answer:

A car moves 100 m in the east direction then 200 m in the northern west direction at an angle of 45°, so the magnitude of the total displacement of the car is approximately ....

ⓐ 135 m   ⓑ 141 m

ⓒ 147 m   ⓓ 158 m

2 If the displacement of a person is 3.1 km in the northern west direction as in the opposite figure, **then calculate** the distance that should be moved by the person from his starting point to the north (s_y) and to the west (s_x) to reach the same destination.



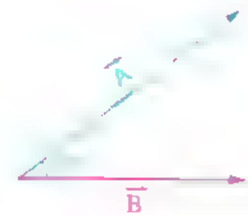
....

....

Third Product of vectors

- There are different forms of finding the product of two vectors:

1 Scalar (dot) product



* The dot product of two vectors $\vec{A}$ and $\vec{B}$ is given by the following relation:

$$\vec{A} \cdot \vec{B} = A\,B\cos\theta$$

- $\cdot$: It is pronounced "dot" and it expresses the scalar product operation
- B : It is the magnitude of vector $\vec{B}$
- A : It is the magnitude of vector $\vec{A}$
- θ : It is the angle between the vectors $\vec{A}$ and $\vec{B}$

* The scalar product of two vectors is a scalar quantity.

If the angle between the two vectors $\vec{A}$ and $\vec{B}$ is:

$\theta = 0°$ (The two vectors are parallel)	$\theta = 90°$ (The two vectors are perpendicular)
Then	Then
$\vec{A} \cdot \vec{B} = AB\cos 0$	$\vec{A} \cdot \vec{B} = AB\cos 90$
$\vec{A} \cdot \vec{B} = AB$ (maximum value)	$\vec{A} \cdot \vec{B} = 0$ (vanished)

Note :

- The scalar product is a commutative operation: $\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A}$

Example 1

There are two vectors $\vec{A}$ and $\vec{B}$ where the angle between them is θ, then the scalar product of the two vectors has a larger value when θ is ………… .

ⓐ 30° ⓑ 45° ⓒ 60° ⓓ 75°

Solution

$\because \vec{A} \cdot \vec{B} = AB \cos\theta$

$\because \cos 30 > \cos 45 > \cos 60 > \cos 75$

$\therefore$ **The correct choice is ⓐ.**

What if the angle between the two vectors was 45° and one of the two vectors rotates by angle ϕ so that the scalar product of them decreases to its half, **what** will be the value of ϕ ?

Example 2

Two vectors $\vec{A}$ and $\vec{B}$ have magnitudes 3 units and 4 units respectively and their scalar product is 12 units, then the angle between the two vectors is ....

ⓐ 0°   ⓑ 45°   ⓒ 90°   ⓓ 180°

Solution

$\vec{A} \cdot \vec{B} = AB \cos\theta$

$12 = 3 \times 4 \cos\theta$, $\therefore \cos\theta = 1$

$\therefore \theta = 0°$

$\therefore$ **The correct choice is ⓐ.**

What if the scalar product of the two vectors $\vec{A}$ and $\vec{B}$ is – 12 units, **what** will be the angle between the two vectors?

Example 3

Two vectors $\vec{A}$ and $\vec{B}$ have horizontal components of 2 units and – 1 unit respectively and vertical components of 3 units and 2 units respectively while the scalar product of the two vectors is 4 units, then the angle between the two vectors is approximately ....

ⓐ 30°   ⓑ 60°   ⓒ 90°   ⓓ 180°

Solution

- The magnitude of vector $\vec{A}$:

$$A = \sqrt{A_x^2 + A_y^2} = \sqrt{(2)^2 + (3)^2} = \sqrt{13} \text{ units}$$

- The magnitude of vector $\vec{B}$:

$$B = \sqrt{B_x^2 + B_y^2} = \sqrt{(-1)^2 + (2)^2} = \sqrt{5} \text{ units}$$

$$\vec{A} \cdot \vec{B} = AB \cos \theta$$

$$4 = \sqrt{13} \times \sqrt{5} \cos \theta$$

$\therefore \theta = 60.26° \simeq 60°$

$\therefore$ **The correct choice is ⓑ.**

What if the horizontal components of the two vectors $\vec{A}$ and $\vec{B}$ don't change and their vertical components change to be 2 units and – 1 unit respectively, **what** will be the scalar product of the two vectors?

7 *Test yourself* — Answered

Choose the correct answer:

There are two vectors $\vec{x}$ and $\vec{y}$ of the same type that have magnitudes of 3 units and 4 units respectively and the magnitude of their resultant is 5 units, then the scalar product of these vectors is ....

ⓐ 12 units ⓑ 6 units ⓒ 5 units ⓓ 0

Vector (cross) product

* When finding the cross product of two vectors $\vec{A}$ and $\vec{B}$ (vector product), we get third vector $\vec{C}$ that is perpendicular to the plane containing both vectors $\vec{A}$ and $\vec{B}$.

* **The vector (cross) product of two vectors $\vec{A}$ and $\vec{B}$ is given by the following relation:**

It is pronounced "cross" and it expresses the vector product operation | It is the magnitude of vector A | It is the smallest angle between the two vectors A and B

$$\vec{C} = \vec{A} \wedge \vec{B} = AB \sin \theta \ \vec{n}$$

It is the resulted vector from the vector product operation | It is the magnitude of vector B | It is a unit vector perpendicular to the plane of both vectors A and B

If the angle between the two vectors $\vec{A}$ and $\vec{B}$ is:

$\theta = 0°$ (The two vectors are parallel)	$\theta = 90°$ (The two vectors are perpendicular)
$\vec{A} \wedge \vec{B} = AB \sin 0\ \vec{n}$	$\vec{A} \wedge \vec{B} = AB \sin 90\ \vec{n}$
$\vec{A} \wedge \vec{B} = 0$ (vanished)	$\vec{A} \wedge \vec{B} = AB\ \vec{n}$ (maximum value)

Then

The vector product of two vectors is a vector quantity of a direction that is determined by using the **right hand rule**.

The right hand rule

Usage:

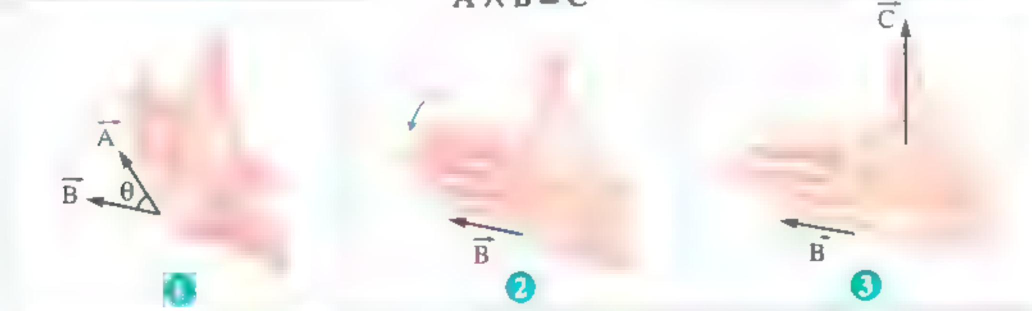
To determine the direction of the vector product $\vec{C}$ of two vectors $\vec{A}$ and $\vec{B}$.

How to apply?

1. The fingers of the right hand are placed in the direction of the first vector.
2. The fingers of the right hand are moved from the first vector towards the second vector through the smallest angle between them (θ).
3. Then, the thumb points to the direction of the vector that represents the vector product of the two vectors.

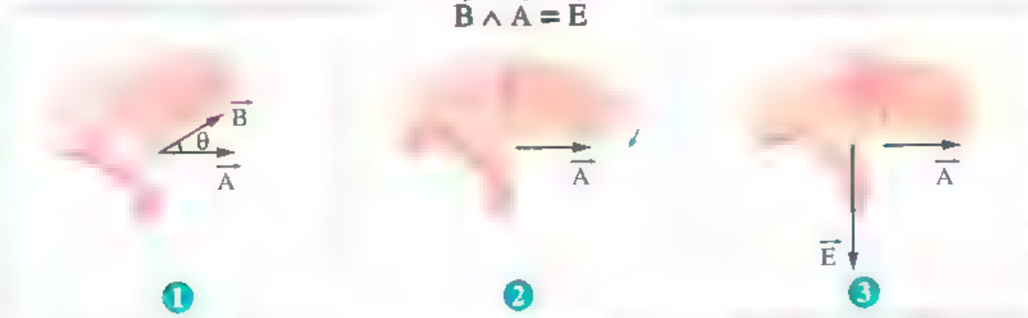
Example (1): In case of:

$$\vec{A} \wedge \vec{B} = \vec{C}$$



Example (2): In case of:

$$\vec{B} \wedge \vec{A} = \vec{E}$$



From the previous examples, we notice that vector $\overrightarrow{E}$ that is the vector product of $(\overrightarrow{B} \wedge \overrightarrow{A})$ has the same magnitude of vector $\overrightarrow{C}$ that is the vector product of $(\overrightarrow{A} \wedge \overrightarrow{B})$ but they are opposite in direction.

Notes :

(1) $\overrightarrow{A} \wedge \overrightarrow{B} \neq \overrightarrow{B} \wedge \overrightarrow{A}$

(2) $\overrightarrow{A} \wedge \overrightarrow{B} = -(\overrightarrow{B} \wedge \overrightarrow{A})$

(3) The scalar product of two vectors equals the magnitude of their vector product when the angle between the two vectors is 45°.

Example 1

If the magnitudes of two vectors $\overrightarrow{A}$ and $\overrightarrow{B}$ are A = 5 units and B = 10 units and the angle between them is 60°, then:

(i) Their scalar product equals ....

ⓐ 15 units ⓑ 20 units ⓒ 25 units ⓓ 30 units

(ii) The magnitude of their vector product equals ....

ⓐ 43.3 units ⓑ 57.8 units ⓒ 83.6 units ⓓ 91.5 units

Solution

(i) $\overrightarrow{A} \cdot \overrightarrow{B} = AB \cos \theta$

$= 5 \times 10 \cos 60° = 25$ **units**

$\therefore$ **The correct choice is ⓒ.**

(ii) $\overrightarrow{A} \wedge \overrightarrow{B} = AB \sin \theta \, \overrightarrow{n}$

$= (5 \times 10 \times \sin 60°) \, \overrightarrow{n} = 43.3 \, \overrightarrow{n}$ **units**

$\therefore$ **The correct choice is ⓐ.**

What if the angle between the two vectors has increased by 30°, **which** product for the two vectors, the scalar product or the vector product will be zero **and which of them** will be maximum?

Example 2

If the magnitude of the vector product of the two vectors $\overrightarrow{A}$ and $\overrightarrow{B}$ equals double their scalar product, then the angle between the two vectors is

ⓐ 30.31° ⓑ 45.32° ⓒ 26.16° ⓓ 63.43°

Solution

$|\vec{A} \wedge \vec{B}| = 2\,(\vec{A} \cdot \vec{B})$

$AB \sin\theta = 2\,AB \cos\theta$

$\frac{\sin\theta}{\cos\theta} = 2$, $\tan\theta = 2$, $\theta = 63.43°$

$\therefore$ **The correct choice is ⓓ.**

Test yourself

Answered

1 Choose the correct answer:

There are two vectors of the same kind $\vec{x}$ and $\vec{y}$ where the angle between them is 180°, so which of the following mathematical operations must equal zero?

ⓐ $\vec{x} + \vec{y}$ ⓑ $\vec{x} - \vec{y}$ ⓒ $\vec{x} \cdot \vec{y}$ ⓓ $\vec{x} \wedge \vec{y}$

2 Two vectors $\vec{A}$ and $\vec{B}$ has magnitudes 3 units and 4 units respectively. If the magnitude of their vector product is 12 units, **then calculate** the angle between the two vectors.

....

....

Questions on Chapter 2

Scalar and Vector Quantities

To watch videos of how to solve questions use the App

GPS

Interactive test

The questions signed by ✦ are answered in detail.

First Multiple choice questions

Scalar quantities and vector quantities

1. Which of the following quantities is a fundamental scalar quantity?

(a) A man weight of 800 N.
(b) A girl displacement of 80 m to east.
(c) A car kinetic energy of 500 J.
(d) An iron piece mass of 60 kg.

2. From the examples of the fundamental vector quantities, ...

(a) the acting force on a body moving to east
(b) the acceleration of a body motion to north
(c) the mass of a static body
(d) the displacement of a moving body

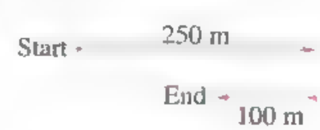
3. Which of the following quantities is a derived vector quantity?

(a) The temperature of a body that is 37°C.
(b) The displacement of a body which is moving to west that is 50 m.
(c) The velocity by which a body moves to east that is 2 m/s.
(d) The kinetic energy of a body that is 10 J.

4. A rat climbs from its burrow up a distance of 4 m on a wall to reach for food, then returns to its burrow again, so its displacement equals ....

(a) 16 m
(b) 8 m
(c) 4 m
(d) zero

5. An athlete covered a displacement of 250 m to east then returned 100 m to west as in the opposite figure. Thus,



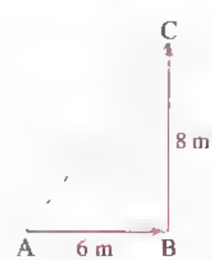
(i) the distance covered by him equals ....

(a) 350 m
(b) 250 m
(c) 150 m
(d) 100 m

(ii) the displacement of the athlete is ....

(a) 350 m to east
(b) 350 m to west
(c) 150 m to east
(d) 150 m to west

6. ✦ An object moved from position A to position B then it changed its direction to reach position C as shown in the opposite figure, so:



(i) The covered distance equals ....

(a) 14 m
(b) 12 m
(c) 10 m
(d) 2 m

(ii) The displacement of the object equals ....

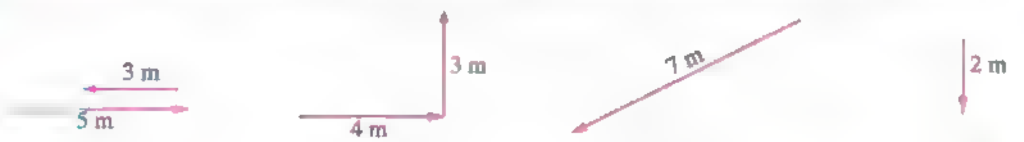
ⓐ 14 m in the direction of $\overrightarrow{AC}$ ⓑ 14 m in the direction of $\overrightarrow{CA}$

ⓒ 10 m in the direction of $\overrightarrow{AC}$ ⓓ 10 m in the direction of $\overrightarrow{CA}$

(iii) The distance and the magnitude of the displacement when the object returns to position A through the same path are .... respectively.

ⓐ 14 m, 28 m ⓑ 28 m, 14 m ⓒ 28 m, 0 ⓓ 14 m, 0

7 ✻ In which of the following cases, the displacement has the largest magnitude?

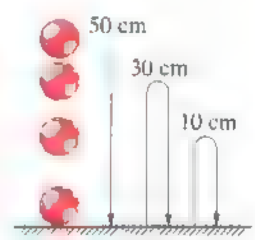


ⓐ ⓑ ⓒ ⓓ

8 ✻ The opposite figure shows a car moving in a curved road. If the total displacement of the car is 2 km, then the distance moved by the car might be ....

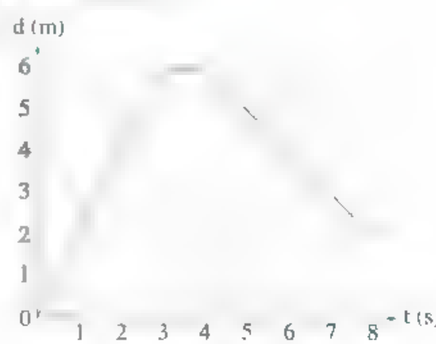
ⓐ 3000 m ⓑ 2 km ⓒ 1.5 km ⓓ 2.7 m

9 ✻ A rubber ball fell from 50 cm high and kept bouncing along a vertical path till it stops as shown in the opposite figure, then ....



	The magnitude of displacement	The distance
ⓐ	50 cm	90 cm
ⓑ	50 cm	130 cm
ⓒ	40 cm	90 cm
ⓓ	40 cm	130 cm

10 ✻ The opposite graph represents the relation between the displacement (d) and the time (t) for a body that moves in a straight line, then:



(i) The total distance covered by the body equals ....

ⓐ 10 m ⓑ 6 m

ⓒ 4 m ⓓ 2 m

(ii) The displacement of the body equals ....

ⓐ 10 m ⓑ 6 m ⓒ 4 m ⓓ 2 m

11 A body moves on a circle of radius r. If it completes two revolutions, so the magnitude of its displacement is ....

ⓐ zero ⓑ r ⓒ 2 r ⓓ 2 πr

12 The magnitude of the displacement of a body moving on a circle when it completes $\frac{1}{4}$ of a revolution is .... the magnitude of its displacement when it completes $\frac{3}{4}$ of a revolution.

ⓐ half ⓑ 3 times ⓒ equal to ⓓ one third of

13 ✳ An object moves on a circle of radius π cm, if the object covered 0.75 of a revolution, then the magnitude of its displacement equals ....

ⓐ $2\sqrt{\pi}$ cm ⓑ $\sqrt{2\pi}$ cm ⓒ $\pi\sqrt{2}$ cm ⓓ $0.75\,\pi$ cm

14 ✳ An object moves on a circle of radius r. The ratio between the distance covered by it and the magnitude of its displacement during $\frac{1}{2}$ of a revolution is ....

ⓐ π ⓑ 2π ⓒ $\frac{\pi}{2}$ ⓓ $\frac{\pi}{4}$

15 ✳ An object moves on a circle of diameter 4 m, then the covered distance and the magnitude of the displacement when the body completes:

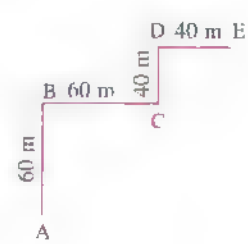
(i) One revolution are ....

	Distance	Magnitude of displacement
ⓐ	8 m	0
ⓑ	12.57 m	0
ⓒ	8 m	8 m
ⓓ	12.57 m	8 m

(ii) 1.75 revolutions are ....

	Distance	Magnitude of displacement
ⓐ	22 m	$2\sqrt{2}$ m
ⓑ	22 m	22 m
ⓒ	9.43 m	$2\sqrt{2}$ m
ⓓ	9.43 m	22 m

16 ✳ In the opposite diagram, a person has moved from point A to point E passing by points B, C and D through the shown path, then:



(i) The displacement of the person equals ....

ⓐ $100\sqrt{2}$ m in the direction of $\overrightarrow{AE}$

ⓑ $40\sqrt{2}$ m in the direction of $\overrightarrow{AE}$

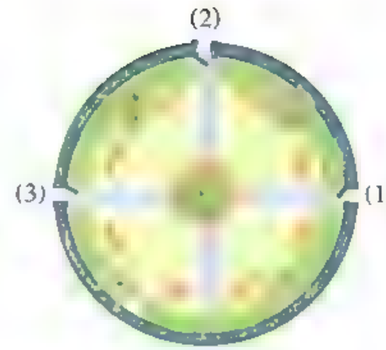
ⓒ $60\sqrt{2}$ m in the direction of $\overrightarrow{CE}$

ⓓ 200 m in the direction of $\overrightarrow{AB}$

(ii) The distance covered by the person equals ....

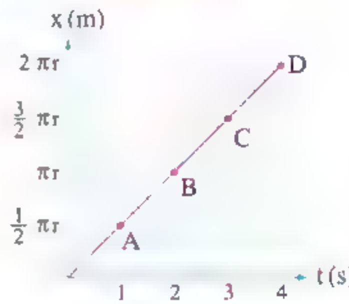
ⓐ 200 m ⓑ 160 m ⓒ $100\sqrt{2}$ m ⓓ 100 m

17 ✳ A man walks around a garden on a circular track near the garden wall as shown in the opposite figure. If the distance moved by the man from gate (1) to gate (2) is 44 m, then the shortest distance between gate (1) and gate (3) is ⋯⋯ .



ⓐ 88 m ⓑ 44 m
ⓒ 56 m ⓓ 28 m

18 ✳ The opposite figure shows the (distance-time) graph for a body moving in a circular path of radius r:



(i) At which point does the magnitude of body's displacement equal 2 r?

ⓐ A ⓑ B
ⓒ C ⓓ D

(ii) The displacement of the body when it reaches point D equals ⋯⋯⋯ m.

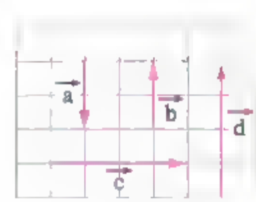
ⓐ $2\pi r$ ⓑ πr ⓒ $\frac{1}{2}\pi r$ ⓓ 0

Representation of vector quantities

19 The correct way of denoting vector A is ⋯⋯⋯

ⓐ $\overline{A}$ ⓑ $\overrightarrow{A}$ ⓒ [A] ⓓ $\mathring{A}$

20 ✳ The opposite figure illustrates multiple vectors, so vector $\vec{a}$ equals ⋯⋯⋯

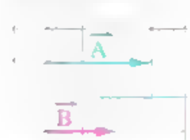


ⓐ $\vec{b}$ ⓑ $-2\vec{b}$
ⓒ $-\frac{1}{2}\vec{c}$ ⓓ $-\frac{1}{2}\vec{d}$

21 The two vectors $\overrightarrow{A}$ and $\overrightarrow{B}$ are equal in the figure ⋯⋯ .

ⓐ

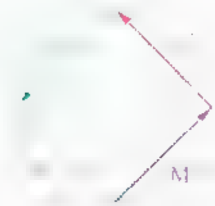
ⓑ



ⓒ

ⓓ

22 In the opposite figure, which pair from the shown vectors $\vec{K}, \vec{L}, \vec{N}$ and $\vec{M}$ are equal?



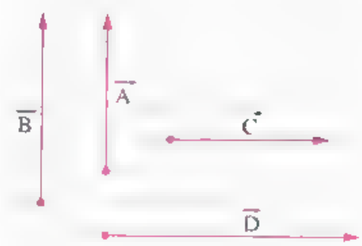
ⓐ $\vec{K}, \vec{L}$

ⓑ $\vec{M}, \vec{N}$

ⓒ $\vec{K}, \vec{M}$

ⓓ $\vec{L}, \vec{N}$

23 ✳ In the opposite figure, there are four vectors that represent quantities of the same type. So, the vector that has the largest magnitude is ....



ⓐ $\vec{A}$

ⓑ $\vec{B}$

ⓒ $\vec{C}$

ⓓ $\vec{D}$

Addition and subtraction of vectors

24 In the opposite figures, the ratio between the force acting on the car by the man in the first case and the force acting on the car by the two men in the second case is ....

First case

Second case

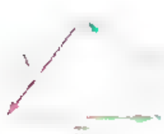
ⓐ greater than 1

ⓑ equal to 1

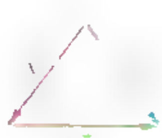
ⓒ less than 1

ⓓ we should know the distance moved by the car in the two cases to determine the answer

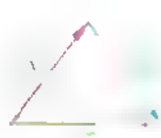
25 The resultant of the two vectors $\vec{A}$ and $\vec{B}$ shown in the opposite diagram is represented by vector $\vec{C}$ in diagram ....



ⓐ



ⓑ



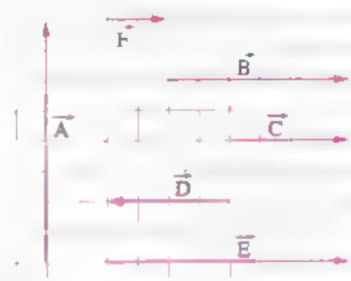
ⓒ

ⓓ

26 The opposite figure represents two vectors $\vec{a}$ and $\vec{b}$. Which of the following figures represents the resultant of subtracting the two vectors $(\vec{b} - \vec{a})$?

ⓐ ⓑ ⓒ ⓓ

27 ✳ The opposite figure represents a group of vectors, so which of the following choices is correct?



ⓐ $\vec{E} = \vec{C} + \vec{B}$

ⓑ $\vec{E} = \vec{C} + 2\vec{F}$

ⓒ $\vec{E} = 3\vec{F} + \vec{D}$

ⓓ $\vec{E} = \vec{A} + \vec{F}$

28 ✳ Two forces act on the same body, one of them is $\vec{F_1}$ in the direction of north with a magnitude of 9 N and the other is $\vec{F_2}$ in the direction of west with a magnitude of 12 N, then the magnitude of the resultant of the two forces F equals ....

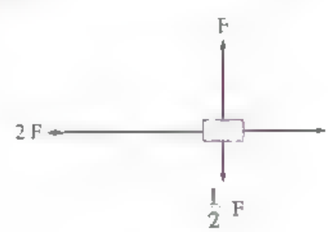
ⓐ 225 N ⓑ $15\sqrt{2}$ N ⓒ 15 N ⓓ $\sqrt{15}$ N

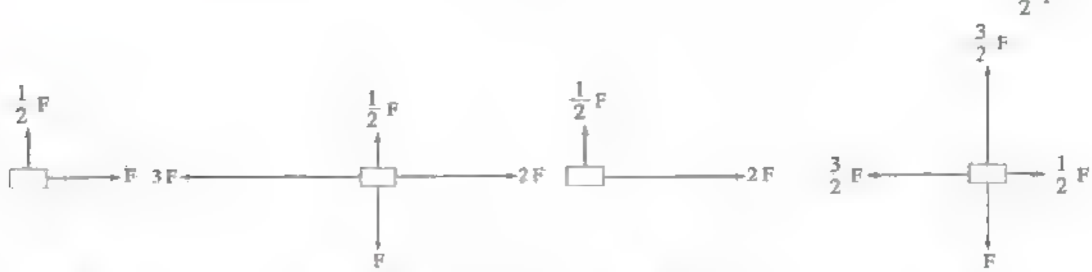
29 ✳ Which of the following choices represents the magnitude and the direction of the resultant of two perpendicular forces $\vec{F_x}$ and $\vec{F_y}$, knowing that they have the same starting point where $F_x = 8$ N, $F_y = 6$ N?

ⓐ 10 N, makes an angle of 36.87° with F_x ⓑ 10 N, makes an angle of 53.13° with F_x

ⓒ 14 N, makes an angle of 36.87° with F_y ⓓ 14 N, makes an angle of 53.13° with F_y

30 ✳ The opposite figure represents a body being affected by several forces. Which one of the following figures represents a body that is affected by the same net force?





ⓐ ⓑ ⓒ ⓓ

31 ✳ A ship sails to north at velocity 12 km/h. Due to tide, it gets deviated to west at velocity 15 km/h, then the magnitude and the direction of the net velocity of the ship are ………. .

(a) 19.21 km/h, 38.66° north of west

(b) 19.21 km/h, 51.34° north of west

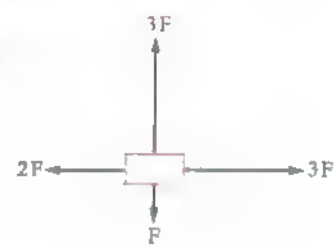
(c) 9 km/h, 51.34° north of west

(d) 9 km/h, 38.66° north of west

32 ✳ Vector $\vec{A}$ has magnitude 5 units and vector $\vec{B}$ has magnitude 4 units, then the magnitude of the resultant of the two vectors $\vec{A}$ and $\vec{B}$ can not be equal to ……… units.

(a) 1 (b) 6.4 (c) 9 (d) 12

33 ✳ In the opposite figure, four forces act on a body, so the magnitude of their resultant and the angle that the resultant makes with the horizontal are ………. respectively.

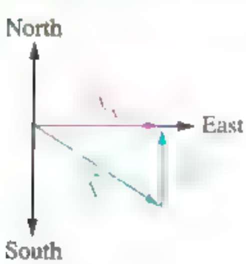


(a) $\sqrt{2}$ F, 63.43° (b) $\sqrt{5}$ F, 37.57°

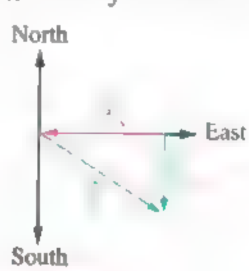
(c) $\sqrt{2}$ F, 37.57° (d) $\sqrt{5}$ F, 63.43°

Resolution of a vector

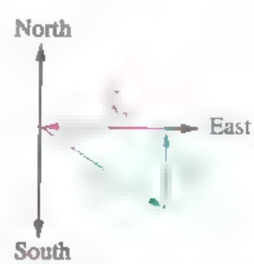
34 A man covered a displacement $\vec{A}$ in the eastern south direction, so the figure that describes the two components $\vec{A}_x$ and $\vec{A}_y$ for vector $\vec{A}$ is ………. .



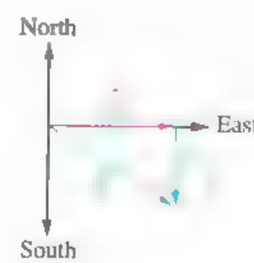
(a)



(b)



(c)



35 ✳ Two perpendicular forces F_x and F_y act on a body. If the magnitude of their resultant is 20 N and its direction makes an angle of 45° with the horizontal force, then:

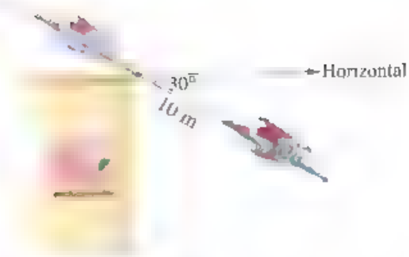
(i) The magnitude of the horizontal force (F_x) is ………. .

(a) $20\sqrt{2}$ N (b) 20 N (c) $\sqrt{2}$ N (d) $10\sqrt{2}$ N

(ii) The magnitude of the vertical force (F_y) is ………. .

(a) $20\sqrt{2}$ N (b) 20 N (c) $10\sqrt{2}$ N (d) $5\sqrt{2}$ N

36 ✻ In the opposite figure:



(i) The horizontal component of the displacement covered by Superman equals ....

ⓐ $5\sqrt{3}$ m ⓑ $5\sqrt{2}$ m

ⓒ 5 m ⓓ 0

(ii) The vertical component of the displacement covered by Superman equals ....

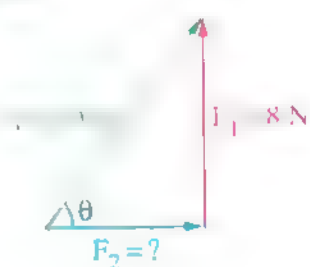
ⓐ $5\sqrt{3}$ m ⓑ $5\sqrt{2}$ m ⓒ 5 m ⓓ 0

37 ✻ A military aircraft had departed the airport to the east, after a while the pilot reported the control tower that the craft is at 21.5 km away in a direction that makes an angle of 22° with the horizontal. So, the vertical height of the craft above the ground and the horizontal distance from the tower at this moment in the east direction respectively are ....

ⓐ 8.1 km, 8.1 km ⓑ 8.1 km, 19.9 km

ⓒ 19.9 km, 19.9 km ⓓ 19.9 km, 8.1 km

38 ✻ In the opposite figure, two perpendicular forces F_1 and F_2 have a resultant (F) of magnitude 10 N, then:



(i) The magnitude of force (F_2) equals ....

ⓐ 164 N ⓑ 36 N

ⓒ 12.8 N ⓓ 6 N

(ii) The value of angle (θ) equals ....

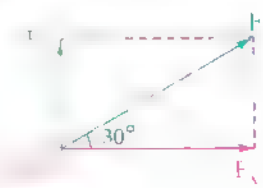
ⓐ 53.13° ⓑ 36.86°

ⓒ 32° ⓓ 12.52°

39 A force (F) makes an angle θ with the horizontal, so the horizontal component (F_x) of this force will be greater than its vertical component (F_y), when ....

ⓐ $\theta < 45°$ ⓑ $\theta = 45°$ ⓒ $45° < \theta < 90°$ ⓓ $\theta = 90°$

40 ✻ In the opposite figure, if force $\vec{F}$ is the resultant of the two forces $\overrightarrow{F_x}$ and $\overrightarrow{F_y}$, then ....



ⓐ $F_x < F_y < F$

ⓑ $F_y < F_x < F$

ⓒ $F < F_y < F_x$

ⓓ $F_y < F < F_x$

41 ✳ The opposite table shows how the magnitude of the net force (F_t) of two forces changes as the angle (θ) between them changes, then the magnitudes of the two forces are .... , ...

F_t (N)	7	5	1
θ	0°	90°	180°

ⓐ 4 N, 3 N ⓑ 6 N, 5 N ⓒ 3 N, 2 N ⓓ 2 N, 1 N

Product of vectors

42 If the magnitudes of the two vectors $\vec{A}$ and $\vec{B}$ are 10 units and 20 units respectively and the angle between them is 60°, then the scalar product of the two vectors equals · units.

ⓐ 200 ⓑ 100 ⓒ 70 ⓓ 50

43 There are two vectors $\vec{A}$ and $\vec{B}$ of magnitudes 8 units and 2 units respectively and the angle (θ) between them is 30°, then the magnitude of their vector product equals .... units.

ⓐ $5\sqrt{3}$ ⓑ 5 ⓒ $8\sqrt{3}$ ⓓ 8

44 The magnitude of the vector product of two vectors vanishes and also their resultant vanishes, if the two vectors are of the same type, have the same magnitude and the angle between them is ....

ⓐ 180° ⓑ 90° ⓒ 45° ⓓ 0°

45 ✳ Two equal vectors of the same type have scalar product of 25 units, then the magnitude of their resultant equals ....

ⓐ 0 ⓑ 5 units ⓒ 10 units ⓓ 25 units

46 ✳ Two vectors of magnitudes 3 units and 5 units have a scalar product of 7.5 units, then their vector product equals · ··

ⓐ 15 $\vec{n}$ units ⓑ 12.99 $\vec{n}$ units ⓒ 7.5 $\vec{n}$ units ⓓ 2.78 $\vec{n}$ units

47 ✳ If the angle between the two vectors $\vec{A}$ and $\vec{B}$ is θ, then $[(\vec{A} \wedge \vec{B}) + (\vec{B} \wedge \vec{A})] =$ ....

ⓐ $AB \sin\theta\, \vec{n}$ ⓑ $2(\vec{A} \cdot \vec{B})$ ⓒ $2(\vec{A} \wedge \vec{B})$ ⓓ zero

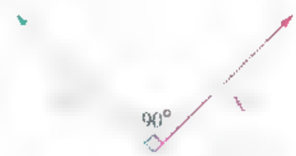
48 The magnitudes of two perpendicular vectors are 3 units and 5 units. If one vector rotates by 60° in the same plane towards the other vector, then the magnitude of the vector product of the two vectors will be .... units.

ⓐ 15 ⓑ $15\sqrt{3}$ ⓒ 7.5 ⓓ 10

49 If the angle between the two vectors $\vec{X}$ and $\vec{Y}$ is 44°, then the ratio between the magnitude of their vector product and their scalar product is ....

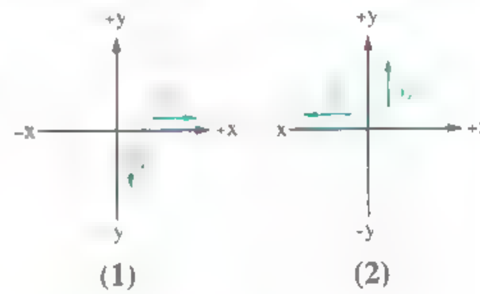
(a) greater than 1
(b) less than 1
(c) equal to 1
(d) there is not enough information

50 ✳ The opposite figure represents two perpendicular vectors $\vec{X}$ and $\vec{Y}$ of the same type and equal magnitudes. Which one of the following operations on the two vectors gives a result that equals zero?



(a) $\vec{X} + \vec{Y}$
(b) $\vec{X} - \vec{Y}$
(c) $\vec{X} \cdot \vec{Y}$
(d) $\vec{X} \wedge \vec{Y}$

51 ✳ If $\vec{F} = \vec{V} \wedge \vec{B}$ and vector $\vec{V}$ is perpendicular to vector $\vec{B}$, so the direction of $\vec{F}$ in the shown two cases is perpendicular to the page and ....



	Case (1)	Case (2)
(a)	into the page	out of the page
	into the page	into the page
(c)	out of the page	into the page
(d)	out of the page	out of the page

1 **Explain the following sentence:**
"The magnitude of the vector product for two vectors has its maximum value when the angle between them is 90°"

2 The opposite figure illustrates two cars A and B starting their motion from the same starting point. **Explain why** the vectors of their displacements aren't equal although they have equal magnitudes.

3 **When does:**
(1) The subtraction of two vectors equal zero?
(2) The magnitude of the vector product of two vectors equal their dot product?

4 Is it possible for the magnitude of a vector to be a negative value? **Explain**.

Questions that measure high levels of thinking

Answered in detail

Choose the correct answer :

1. The opposite graph represents the relation between the displacement of a body that moves in a straight line and the time, then:

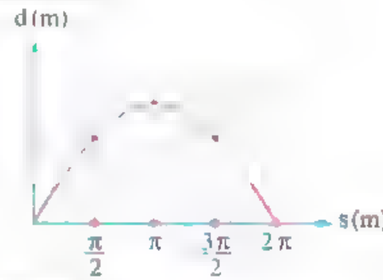
(i) The total displacement of the body is ……….

ⓐ 50 m ⓑ – 50 m
ⓒ 10 m ⓓ – 10 m

(ii) The total distance covered by the body is ……….

ⓐ 50 m ⓑ – 50 m ⓒ 10 m ⓓ – 10 m

2. The opposite graph represents the relation between the displacement (d) and the distance (s) covered by a body moving in a circular path, so the radius of this circular path is ……….



ⓐ 2 m ⓑ 1 m
ⓒ $\sqrt{2}$ m ⓓ π m

3. A boy rides his bicycle starting from point A and moves a distance of 4.55 km to the east, then he takes a circular path whose center is point A and he moves in clockwise direction till he reaches point B which is located directly at the south of point A, after that he moves a distance 1.8 km to north till he reaches point C, then:

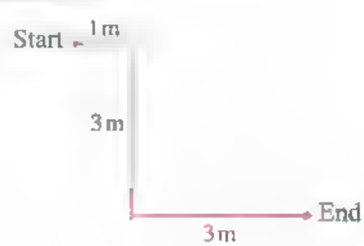
(i) The displacement of the boy from point A equals ……….

ⓐ 6.35 km in the direction of $\overrightarrow{AC}$ ⓑ 4.55 km in the direction of $\overrightarrow{BC}$
ⓒ 2.75 km in the direction of $\overrightarrow{AC}$ ⓓ 1.8 km in the direction of $\overrightarrow{BC}$

(ii) The total distance covered by the boy equals ………….

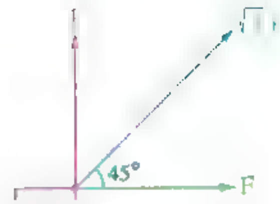
ⓐ 13.5 km ⓑ 20.65 km ⓒ 6.35 km ⓓ 2.75 km

4. If a body moves as the path shown in the opposite figure, so the distance covered by the body and the magnitude of its displacement are ………. respectively.



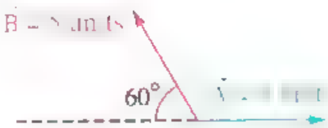
ⓐ 6 m, 3 m ⓑ 7 m, 7 m
ⓒ 7 m, 5 m ⓓ 7 m, 4 m

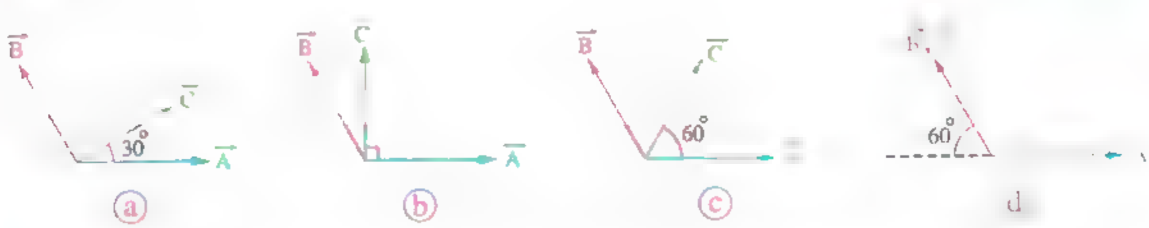
5. In the opposite figure, three forces act on a body, so the magnitude of their resultant is ....



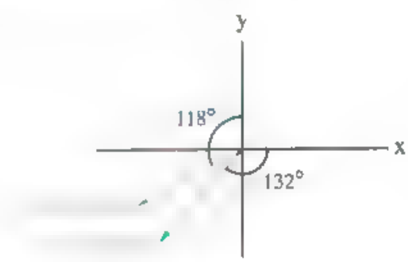
ⓐ 2 F
ⓑ 3.414 F
ⓒ $2\sqrt{2}$ F
ⓓ $\sqrt{5}$ F

6. If the resultant of the two vectors $\vec{A}$ and $\vec{B}$ shown in the opposite figure is vector $\vec{C}$, which figure of the following figures represents vector $\vec{C}$?





7. In the opposite figure, the scalar product of the two vectors $\vec{F}$ and $\vec{r}$ equals ....



ⓐ 194.07 N.cm
ⓑ 421.69 N.cm
ⓒ 533.22 N.cm
ⓓ 550.58 N.cm

8. There are two vectors $\vec{A}$ and $\vec{B}$, where the magnitude of vector $\vec{A}$ is double the magnitude of vector $\vec{B}$ and the magnitude of their vector product equals 13.5 units while their scalar product equals $4.5\sqrt{3}$ units, then:

(i) The angle between the two vectors equals ....

ⓐ 90° ⓑ 60° ⓒ 45° ⓓ 30°

(ii) The magnitude of vector $\vec{A}$ equals ....

ⓐ 2.12 units ⓑ 2.35 units ⓒ 4.24 units ⓓ 5.58 units

9. If $\vec{a} \cdot \vec{b} = \vec{a} \cdot \vec{c}$, so which of the following relations should be correct?

(Knowing that: θ is the angle between $\vec{a}$ and $\vec{b}$, ϕ is the angle between $\vec{a}$ and $\vec{c}$)

ⓐ $\vec{b} = \vec{c}$
ⓑ $\cos\theta = \cos\phi$
ⓒ $b\cos\theta = c\cos\phi$
ⓓ $\vec{a} = \vec{b} + \vec{c}$

Test on Chapter 2

Scalar and Vector Quantities

First Choose the correct answer

1 The magnitude of the vector product of the two vectors $\overrightarrow{A}$ and $\overrightarrow{B}$ in figure (1) is .... of the two vectors $\overrightarrow{A}$ and $\overrightarrow{B}$ in figure (2).

Figure (1) Figure (2)

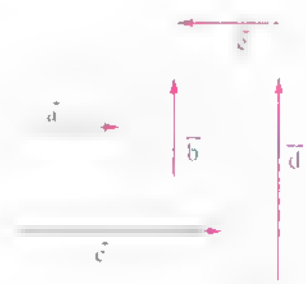
ⓐ greater than the magnitude of the vector product

ⓑ less than the magnitude of the vector product

ⓒ equal to the magnitude of the vector product

ⓓ equal to the scalar product

2 The following figure represents a group of vectors, then vector $\overrightarrow{c}$ equals ....



ⓐ $1.5\,\overrightarrow{b}$

ⓑ $-2\,\overrightarrow{e}$

ⓒ $\overrightarrow{d}$

ⓓ $-2\,\overrightarrow{a}$

3 If the distance covered by a body moving in a circular path after $\frac{1}{8}$ revolution is 22 m, then its displacement during $\frac{1}{4}$ revolution equals ....

ⓐ 28 m ⓑ 44 m

ⓒ $14\sqrt{2}$ m ⓓ $28\sqrt{2}$ m

4 In the opposite figure, there are two perpendicular forces F_x and F_y, so the value of angle θ is ....

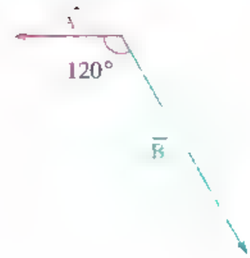
ⓐ 30°

ⓑ 60°

ⓒ 45°

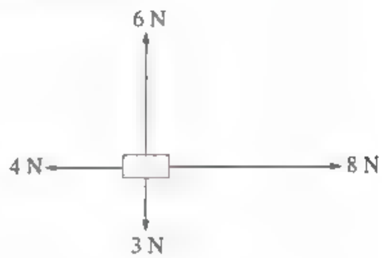
ⓓ 90°

5 The opposite figure shows two vectors $\overrightarrow{A}$ and $\overrightarrow{B}$ that have magnitudes of 50 units and 150 units respectively. The magnitude and the direction of their vector product ($\overrightarrow{A} \wedge \overrightarrow{B}$) are ·········· and ·········· respectively.



ⓐ 6495.19 units, perpendicular into the page
ⓑ 6495.19 units, perpendicular out of the page
ⓒ 3750 units, perpendicular into the page
ⓓ 3750 units, perpendicular out of the page

6 The opposite figure shows four forces acting on a body, so the magnitude and the direction of their resultant are ·········· and ·········· respectively.

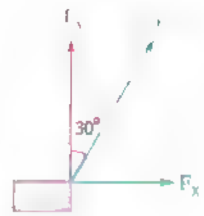


.. 8 N, makes angle 53.13° with the horizontal
ⓑ 8 N, makes angle 45° with the horizontal
ⓒ 5 N, makes angle 36.87° with the horizontal
ⓓ 5 N, makes angle 30° with the horizontal

7 If the Earth orbits the Sun in a circular path of radius 1.5×10^{11} m and it completes one revolution every solar year, then the magnitude of the displacement of the Earth during three months is ·········· . (Neglecting the motion of the Sun)

ⓐ $\sqrt{2} \times 10^{11}$ m ⓑ 3×10^{11} m
ⓒ $2\sqrt{2} \times 10^{11}$ m ⓓ 2.12×10^{11} m

8 In the opposite figure, force F is the resultant of the two forces F_x and F_y, then ··········

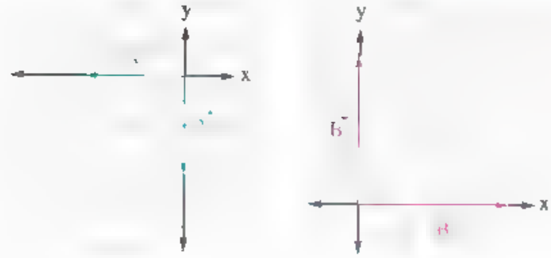


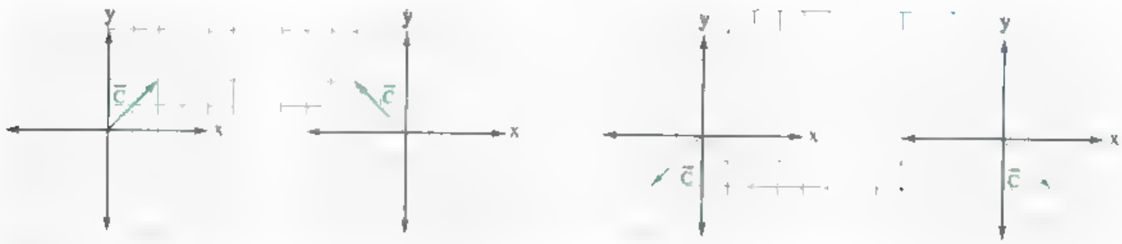
ⓐ $F_x < F_y < F$
ⓑ $F_y < F_x < F$
ⓒ $F < F_y < F_x$
ⓓ $F_y < F < F_x$

9 If a body moves in the shown path, then the magnitude of the displacement and the distance covered by it are ·········· and ·········· respectively.

ⓐ 50 m, 50 m ⓑ 50 m, 90 m
ⓒ 90 m, 90 m ⓓ 90 m, 20 m

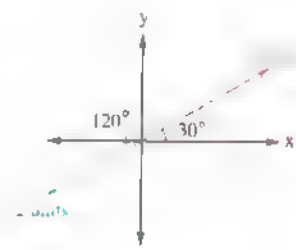
10 The opposite figures represent the components of vectors $\vec{A}$ and $\vec{B}$, so which of the following figures may represent the resultant of the two vectors?





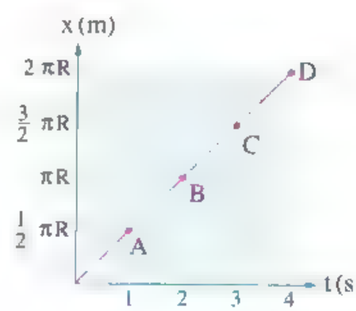
(a) (b) (c) (d)

11 Two vectors of magnitudes 2 units and 2.5 units have directions as shown in the opposite figure, so the scalar product of the two vectors equals ....



(a) 0
(b) $\frac{-5\sqrt{3}}{2}$ units
(c) – 5 units
(d) 5 units

12 The opposite graph of distance versus time represents the motion of a body in a circular path of radius R, so the ratio between the magnitude of its displacement when it reaches point A and the magnitude of its displacement when it reaches point B equals ....

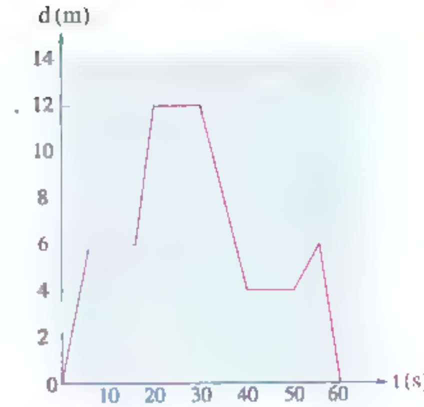


(a) $\frac{1}{1}$
(b) $\frac{\sqrt{2}}{2}$
(c) $\sqrt{2}$
(d) $\frac{1}{2}$

13 The opposite figure shows two vectors $\vec{A}$ and $\vec{B}$, where A = 8 cm and the resultant of the two vectors is perpendicular to $\vec{A}$, so the magnitude of vector $\vec{B}$ equals ....

(a) $4\sqrt{2}$ cm
(b) 4 cm
(c) 8 cm
(d) $8\sqrt{2}$ cm

14 The opposite (displacement-time) graph describes the motion of a man moving in a straight track, so the distance covered by the man equals ....



ⓐ 0

ⓑ 12 m

ⓒ 26 m

ⓓ 28 m

Second Answer the following questions

15 **Which of the following mathematical expressions is right? And which is wrong?**

(1) $(\vec{A} + \vec{B}) + (\vec{B} \cdot \vec{C})$

(2) $(\vec{A} \cdot \vec{B}) + (\vec{B} \wedge \vec{C})$

16 Vector $\vec{A}$ has a horizontal component of 4 cm and a vertical component of – 7.5 cm. Vector $\vec{B}$ has a horizontal component of – 2.5 cm and a vertical component of 5 cm. If $\vec{C} = \vec{A} + \vec{B}$, **find** the components of vector $\vec{C}$.

Accumulative Test on Unit 1

Physical Quantities and Measuring Units

First Choose the correct answer

1. Which statement using prefixes of the base unit meter (m) is not correct?

(a) $1\ pm = 10^{-12}\ m$
(b) $1\ nm = 10^{-9}\ m$
(c) $1\ Mm = 10^{6}\ m$
(d) $1\ Gm = 10^{12}\ m$

2. The best way to judge the accuracy of measurement is through ....

(a) the absolute error
(b) the relative error
(c) the product of the relative error and the absolute error
(d) all of them

3. If the vector product of two vectors $\vec{A} \wedge \vec{B} = \vec{C}$, hence $\vec{A} \cdot \vec{C} =$ ....

(a) $\vec{A}$
(b) $\vec{B}$
(c) $\vec{C}$
(d) 0

4. If the kinetic energy of a body is given by the relation $\frac{1}{2}\ mv^2$, then its dimensional formula is ....

(a) $ML^2\ T^2$
(b) $ML\ T^{-2}$
(c) $ML^{-1}\ T^{-2}$
(d) $ML^2\ T^{-2}$

5. The vernier caliper is used in measuring ....

(a) small masses
(b) the distance between cities
(c) small lengths
(d) large intervals of time

6. For the resultant of two vectors to be maximum, the angle between them must be ....

(a) 0°
(b) 60°
(c) 90°
(d) 180°

7. If two forces $F_1 = 4\ N$ and $F_2 = 3\ N$ acted on a body, then the net force on the body is ....

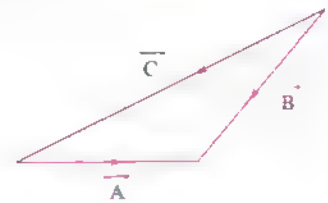
(a) 7 N
(b) 5 N
(c) 1 N
(d) between 1 N and 7 N

8 Two vectors $\overrightarrow{F_x}$ and $\overrightarrow{F_y}$ are perpendicular, if F_x is double vector F_y, so the angle θ between the resultant vector and $\overrightarrow{F_x}$ equals ....

ⓐ 26.56° ⓑ 30°

ⓒ 60° ⓓ 63.43°

9 Which of the following choices describes the opposite figure?



ⓐ $\vec{A} + \vec{B} = \vec{C}$

ⓑ $\vec{B} + \vec{C} = \vec{A}$

ⓒ $\vec{C} + \vec{A} = \vec{B}$

ⓓ $\vec{A} + \vec{B} + \vec{C} = 0$

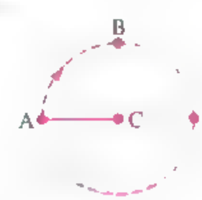
10 Hassan measured the length of a building by a meter tape, it was found to be (10 ± 0.1) m, then ....

	The type of measurement	The absolute error	The relative error
ⓐ	direct	10 m	0.01
ⓑ	direct	0.1 m	0.01
ⓒ	indirect	10 m	0.001
ⓓ	indirect	0.1 m	10.1

11 The atom of gold has a diameter of 0.26 nm and the diameter of its nucleus is 5.6×10^{-3} pm, so the ratio of the diameter of the atom to that of its nucleus equals ....

ⓐ 46.43 km ⓑ 46.43×10^3 ⓒ 46.43×10^3 m ⓓ 46.43

12 In the opposite figure:



If a body moved on the circle from point A to point B, the ratio between the covered distance and the displacement of the body equals ....

ⓐ $\frac{\pi}{2}$ ⓑ π ⓒ $\frac{\pi}{2\sqrt{2}}$ ⓓ $\frac{\pi}{\sqrt{2}}$

13 If x = (5 ± 0.1) m and y = (7 ± 0.2) s, so $(\frac{x}{y})$ equals ....

ⓐ $(71 \pm 3.4)\ 10^{-2}$ m/s ⓑ (0.71 ± 0.034) m

ⓒ (0.71 ± 0.3) m/s ⓓ (0.71 ± 0.3) m

14 If the relative error in measuring the area of a room is 0.04 and the actual area is 45 m^2, the absolute error in measuring the area is ....

(a) 0.45 m^2 (b) 0.45 (c) 1.8 (d) 1.8 m^2

Answer the following questions

15 Cylinder of radius 5 cm and height 20 cm, is made of iron of density 7800 kg/m^3, **find:**

(a) The volume of the cylinder in nm^3.

(b) The mass of the cylinder in mg.

16 Two equal magnitudes of forces $|\overrightarrow{F_1}| = |\overrightarrow{F_2}|$ act on an object. If their resultant has a magnitude of 35 N and makes an angle 45° to $\overrightarrow{F_1}$, **find:**

(a) The magnitudes of F_1 and F_2

(b) The dot product and the cross product of the two forces.

Unit Two

Linear Motion

Chapters of the unit

Chapter 1

Motion in a Straight Line.

Lesson One | Moti[illegible]

Lesson Two | Acc[illegible]

- Test on Chapter 1

Chapter 2

Motion with Uniform Acceleration.

Lesson One | E[illegible]

Lesson Two | A[illegible]

Lesson [illegible] | [illegible]

- Test on Chapter 2

Chapter 3

Force and Motion.

- Test on Chapter 3

- [illegible] Test on Units [illegible]

Objectives of the unit

By the end of this unit, the student should be able to:

Chapter 1

- Define the concept of motion in a straight line.
- Identify the types of motion.
- Plot and explain the different graphs that represent the relationships: (displacement–time) and (velocity–time).
- Differentiate and compare the types of velocity.
- Inquire, analyze and explain the graphical representations related to linear motion.

Chapter 2

- Deduce the equations of motion at uniform acceleration.
- Identify the motion of objects under free fall.
- Conclude the motion in two dimensions such as projectile motion.
- Design an experiment to determine the free fall acceleration

Chapter 3

- Define the concept of force and inertia.
- Explain the action – reaction coupling

Chapter 1

Lesson One

Motion and Velocity

Motion

- **The concept of motion** is related to the change in the position of an object relative to another static object (reference point) as time passes, then when the position of the first object changes relative to the second object (static) as time passes, we can say that the first object is moving.

Static object

- The motion of an object can be represented by: taking a series of successive photos on equal intervals of time and by putting these photos in one photo, we get a pattern that shows the sequence of motion which is called the motion diagram.

Enrichment information

For simplicity, any body is treated as a point, neglecting by that the internal structure, the volume and the geometrical shape of the body even if this body is a person or a galaxy.

Types of Motion

- Motion can be classified into two main types:

1 Translational motion

- It is the motion which is characterized by having a starting point and an end point.

2 Periodic motion

- It is the motion that repeats itself over equal intervals of time.

Examples

Motion in a straight line (the simplest type of motion, it may be horizontal, vertical or on an inclined plane):

For example:

- The train motion.
- The motion of a ball on a horizontal plane.

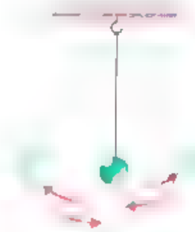
Projectile motion:

For example: The motion of a cannonball projected from the nozzle of a cannon.

Vibrational motion:

For example:

- The pendulum motion.
- The motion of the strings of the musical instruments.



Circular motion:

For example:

- The rotation of the Moon around the Earth.
- The motion of a mass tied to a thread and moving in a circular path to complete one or multiple revolutions.

Example

Which of the following choices represents a translational motion?

ⓐ Simple pendulum motion during 10 complete vibrations.

ⓑ The Earth's motion around the Sun during 3 years.

ⓒ The apparent motion of the Sun during 4 hours.

ⓓ The Moon's motion around its axis during one lunar month.

Solution

- Choices ⓐ, ⓑ, ⓓ represent periodic motions because each of them repeats itself over equal intervals of time.
- Choice ⓒ represents a translational motion because the apparent motion of the Sun is due to the rotation of Earth around its axis that is repeated every 24 hours. So, after 4 hours the Sun will be translated apparently at the horizon from one point to another.

∴ **The correct choice is ⓒ.**

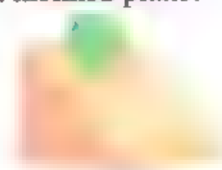
Test yourself

Answered

Determine the type of motion of each of the following bodies:

1 The motion of the planets around the Sun.

2 The motion of a box which is sliding on an inclined plane.

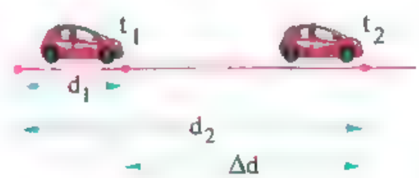


3 The motion of a mass which is attached to a spring.

Now we will study some concepts that are related to the motion in a straight line such as velocity and acceleration.

Velocity (v)

- If a car moves to cover a distance in a certain direction (displacement) Δd in time interval Δt, the motion of this car can be described using different physical concepts such as speed and velocity as follows:

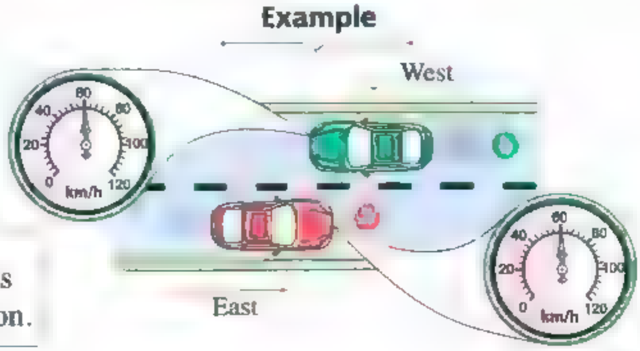


The difference between the speed and the velocity of a body:

1 Speed	2 Velocity
The **distance** moved by the object per unit of time.	The time rate of change in the **displacement** of the object.
Scalar quantity; defined by its magnitude only.	**Vector quantity**; defined by both magnitude and direction.
Always positive.	Could be positive in a certain direction and negative in the opposite direction.

The unit of measurement in the SI system is m/s and its dimensional formula is LT^{-1}.

Example



Assume that :

The east direction is the positive direction.

From the previous figure, we find that:

- **The speed** for both cars (a), (b) is 60 km/h,
while **the velocity** of car (a) is + 60 km/h since it moves eastwards,
and **the velocity** of car (b) is 60 km/h since it moves westwards.

Types of velocity

1 Uniform (constant) velocity

- The velocity by which the object moves through **equal displacements** in equal intervals of time, where the object moves at a velocity of constant magnitude in one direction (straight line).

2 Non-uniform (variable) velocity

- The velocity by which the object moves through **unequal displacements** in equal intervals of time, where the velocity changes its magnitude or direction or both of them.

Motion diagram (The arrow represents the velocity vector)

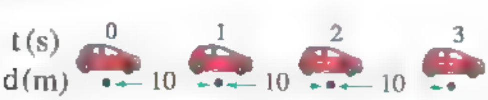
(The magnitude of velocity is constant and the body moves in constant direction)

(The magnitude of the velocity is variable and the body moves in constant direction)

(The magnitude of the velocity is constant and the body changes its direction of motion)

Example

- A car is moving as shown in the figure according to the data given in the table below:



d (m)	0	10	20	30	40	50
t (s)	0	1	2	3	4	5

- A car has moved from rest as shown in the figure according to the data given in the table below:

d (m)	0	1	4	9	16	25
t (s)	0	1	2	3	4	5

From the previous table, the velocity can be determined from the relation: $v = \frac{\Delta d}{\Delta t}$

$$v_1 = \frac{10-0}{1-0} = 10 \text{ m/s}$$
$$v_2 = \frac{20-10}{2-1} = 10 \text{ m/s}$$
$$v_3 = \frac{30-20}{3-2} = 10 \text{ m/s}$$
$$v_4 = \frac{40-30}{4-3} = 10 \text{ m/s}$$
$$v_5 = \frac{50-40}{5-4} = 10 \text{ m/s}$$

The velocity has **a constant** magnitude

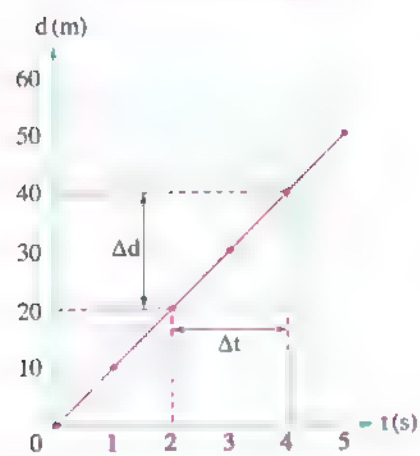
$$v_1 = \frac{1-0}{1-0} = 1 \text{ m/s}$$
$$v_2 = \frac{4-1}{2-1} = 3 \text{ m/s}$$
$$v_3 = \frac{9-4}{3-2} = 5 \text{ m/s}$$
$$v_4 = \frac{16-9}{4-3} = 7 \text{ m/s}$$
$$v_5 = \frac{25-16}{5-4} = 9 \text{ m/s}$$

The velocity has **a variable** magnitude

Graphical representation

When plotting the relation between the displacement (d) on the ordinate (y-axis) and time (t) on the abscissa (x-axis) $\boxed{\text{(d-t) curve}}$, we get:

A straight line



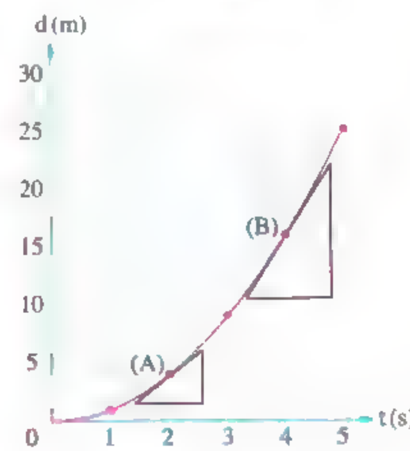
- The slope of the straight line gives the magnitude of the uniform velocity at which the object moves:

$$\text{Slope} = v = \frac{\Delta d}{\Delta t} = \frac{40-20}{4-2} = 10 \text{ m/s}$$

Integration with Mathematics

You can revise how to calculate the slope of a straight line from section (8) page (13).

A curve



- The slope of the tangent drawn to the curve at any point gives the magnitude of the instantaneous velocity of the object at this point:

- The velocity of the car at t = 2 s

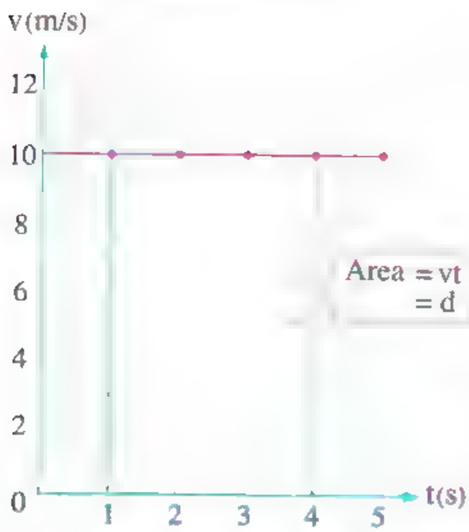
$$\text{Slope at (A)} = v_A = \frac{\Delta d_1}{\Delta t_1} = \frac{6.1-1.5}{2.6-1.45} = 4 \text{ m/s}$$

- The velocity of the car at t = 4 s

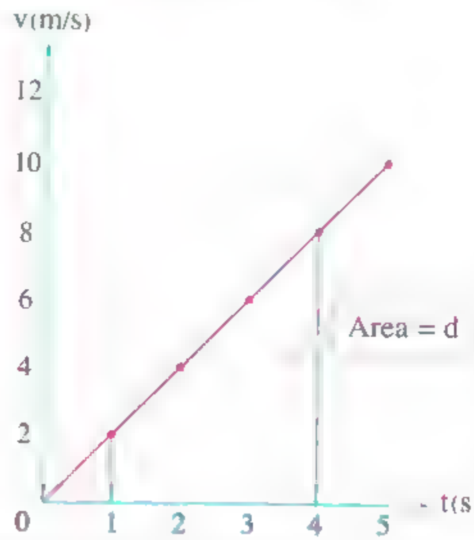
$$\text{Slope at (B)} = v_B = \frac{\Delta d_2}{\Delta t_2} = \frac{22-10.4}{4.8-3.35} = 8 \text{ m/s}$$

When plotting the relation between the velocity (v) on the vertical axis and the time (t) on the horizontal axis $\boxed{\text{(v-t) curve}}$, we get:

A straight line parallel to the horizontal axis



A straight line inclined to the horizontal

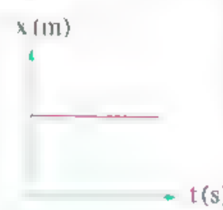


The area under any part of the (velocity-time) curve represents the displacement of the body during this interval

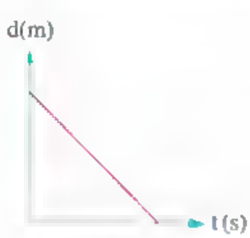
Notes :

(1) When we study the motion of a body, we assume that a certain direction is the positive direction of motion. If the body moves in this direction, its velocity will be positive and if the body moves in the opposite direction, its velocity will be negative.

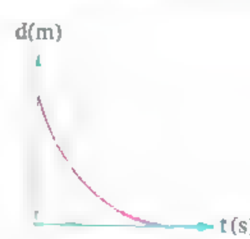
(2) The graphical relation between the position (x) of the body and the time (t) for a static body is represented by a horizontal line parallel to the time axis (Slope = 0).



(3) If the object was moving towards a fixed point (reference point), then the graphical relation between the displacement of the object from this point (d) and time (t) becomes as follows:



The object is moving with **uniform velocity**.



The object is moving with **non-uniform velocity**.

Example 1

An athlete runs in a straight path with uniform velocity to cover a distance of 20 m in 4 s, so the velocity of the athlete equals ....

ⓐ 2.5 m/s ⓑ 5 m/s ⓒ 7.5 m/s ⓓ 10 m/s

Solution

$\Delta d = 20$ m $\Delta t = 4$ s $v = ?$

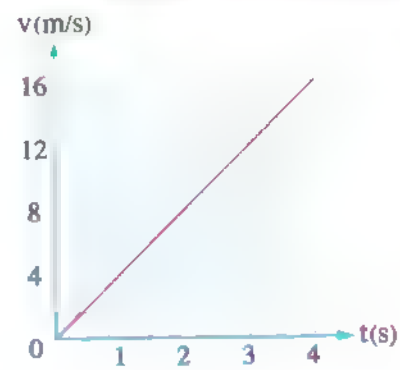
$v = \frac{\Delta d}{\Delta t} = \frac{20}{4} = 5$ m/s

∴ **The correct choice is ⓑ.**

What if you are asked to determine the time taken by the athlete to cover 100 m when he is moving with the same velocity, **what** will be your answer?

Example 2

The opposite graph represents the relation between the velocity (v) and the time (t) of a car that moves from rest in a straight line, so the displacement of the car during the first three seconds equals ....



ⓐ 6 m ⓑ 9 m

ⓒ 18 m ⓓ 32 m

Solution

Clue

The displacement of the car is found by calculating the area under the (velocity-time) curve

The area under the curve $= \frac{1}{2} \times$ base $\times$ height

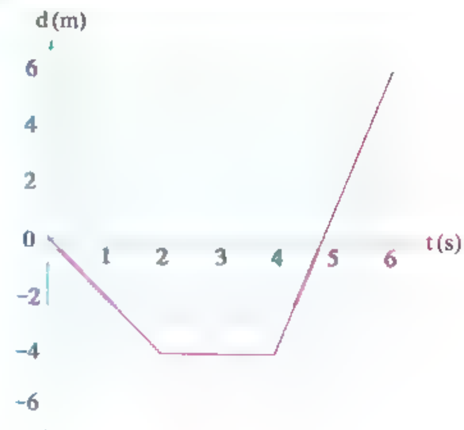
$d = \frac{1}{2} \times 3 \times 12 = 18$ m

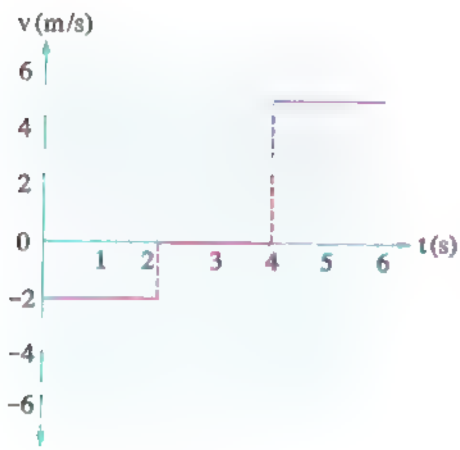
∴ **The correct choice is ⓒ.**

What if you are asked to determine the distance covered by the car from $t = 0$ to $t = 4$ s, **what** will be your answer?

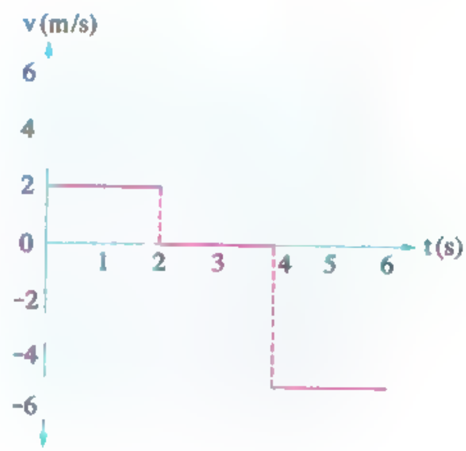
Example 3

The opposite graph represents the relation between the displacement (d) and the time (t) of a body that moves in a straight line, so which of the following graphs represents the relation between the velocity of the body (v) and the time (t) during the same interval of time?

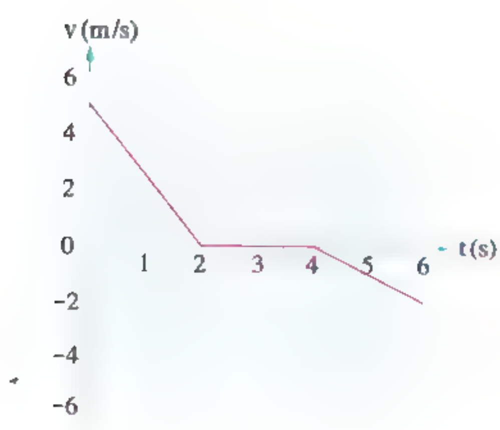




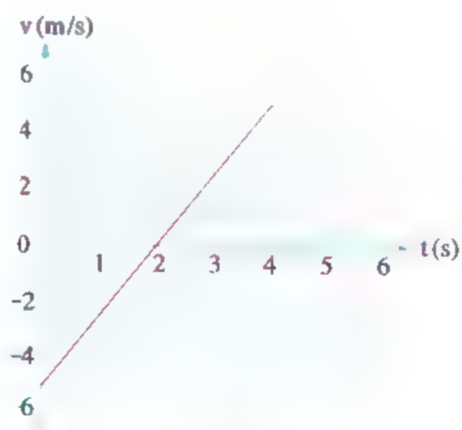
ⓐ



ⓑ



ⓒ



ⓓ

Solution

Clue

To determine the (velocity-time) graph for this body we should analyze the (displacement-time) graph and calculate the velocity of the body in each interval in it.

- From $t = 0$ to $t = 2$ s, the body moves with uniform negative velocity (v_1):

$$v_1 = \frac{\Delta d_1}{\Delta t_1} = \frac{-4-0}{2-0} = -2 \text{ m/s}$$

- From $t = 2$ s to $t = 4$ s, the body is static which means its velocity equals zero.
- From $t = 4$ s to $t = 6$ s, the body moves with uniform positive velocity (v_2):

$$v_2 = \frac{\Delta d_2}{\Delta t_2} = \frac{6-(-4)}{6-4} = 5 \text{ m/s}$$

$\therefore$ **The correct choice is ⓐ.**

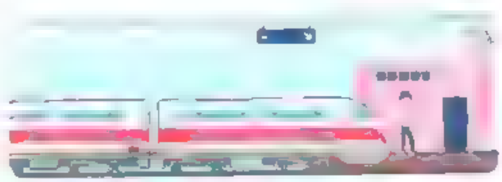
What if you are asked to determine the instant at which the body reverses its direction of motion, **what** will be your answer?

Test yourself

Answered

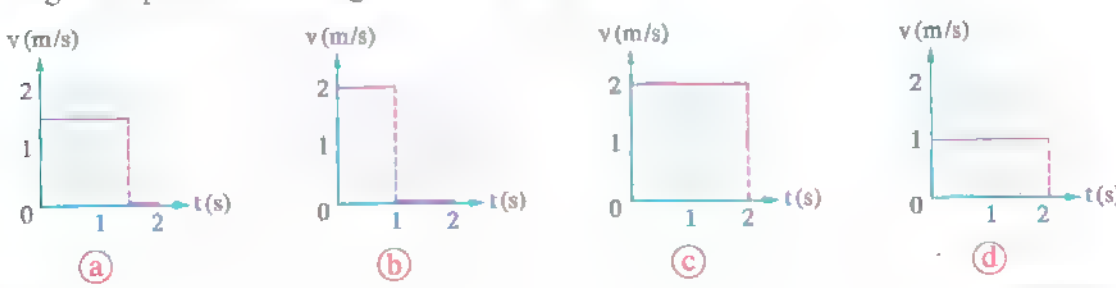
Choose the correct answer:

1 ✱ The opposite figure shows a man who stands on the platform of a train station, where he observes a train that moves with a uniform velocity of 30 m/s. If the train takes 3 s to pass till its end in front of the man, so the length of the train is ______.

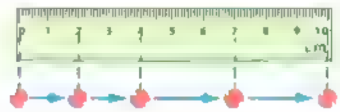


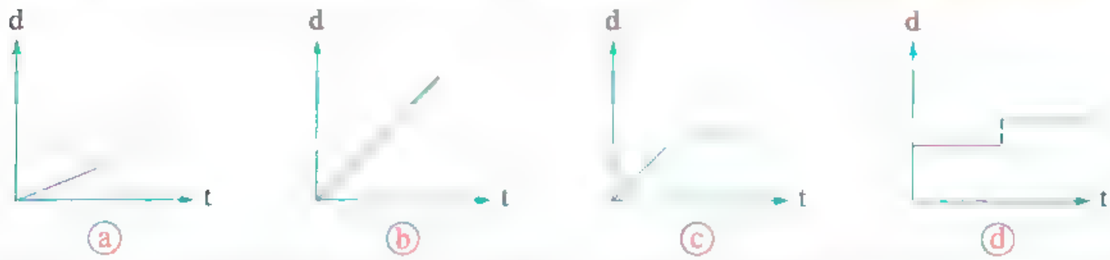
ⓐ 10 m ⓑ 27 m ⓒ 30 m ⓓ 90 m

2 The following graphs represent the relation between the velocity and the time of four bodies that move during the same interval of time, so which of these bodies has the largest displacement during the time of its motion?



3 The opposite motion diagram represents the motion of a body during equal intervals of time, so which of the following graphs describes the motion of this body?



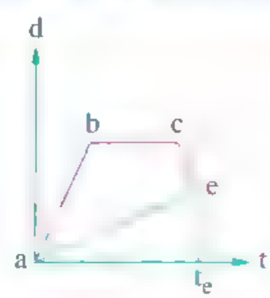


⊙ When an object moves at non uniform (variable) velocity:

1. The velocity of the object at a certain instant is called the instantaneous velocity (v).
2. The average of the body's velocity during a certain interval of time is called the average velocity ($\bar{v}$).

Also, the average of the body's speed during a certain interval of time is called the average speed which is different than the average velocity as follows:

1 Average velocity	**2** Average speed
The ratio between the total displacement of the body and the time of this displacement.	The ratio between the total distance covered by the body and the time of covering this distance.
The type of the quantity	
Vector quantity that has the same direction of the displacement.	Scalar quantity.
Mathematical relation	
$\text{Average velocity} = \dfrac{\text{Total displacement}}{\text{Total time}}$	$\text{Average speed} = \dfrac{\text{Total distance}}{\text{Total time}}$
How to calculate it from the (displacement-time) graph	



$v = \dfrac{d_{ae}}{t_e}$	$v_{speed} = \dfrac{d_{ab} + d_{bc} + d_{ce}}{t_e}$

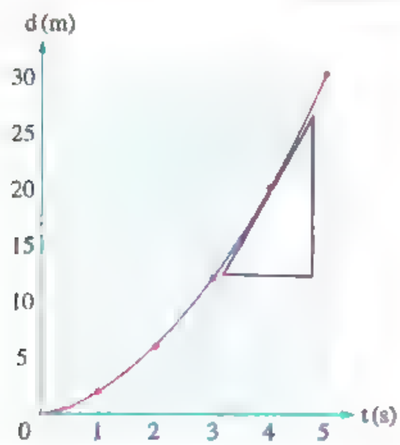
Here, we can define the instantaneous velocity by comparing it with the average velocity as follows:

❶ Instantaneous velocity (v)	❷ Average velocity ($\bar{v}$)
The velocity of the object at a given instant and it is defined by the time rate of change in displacement through a time interval that approaches zero.	The total displacement of the object from the starting point to the end point of a definite time interval divided by that total time interval.

The mathematical relation

It is determined from the slope of the tangent of the (displacement-time) curve at a certain instant.	$\bar{v} = \frac{d \text{ (Total displacement)}}{t \text{ (Total time)}}$

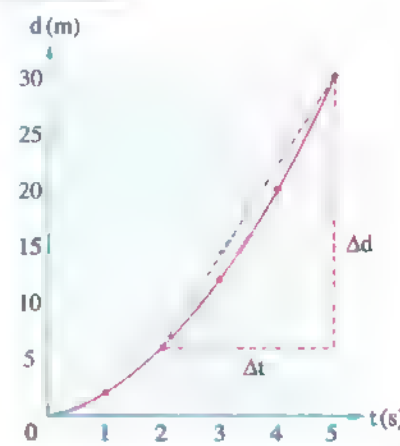
Graphical representation



The instantaneous velocity of an object at an instant is given by the slope of the tangent drawn to the curve at the point corresponding to that instant.

$$\text{Slope of tangent} = v = \frac{26.5 - 12.5}{4.8 - 3.2} = 8.75 \text{ m/s}$$

Which means that: The instantaneous velocity at t = 4 s is 8.75 m/s.



The average velocity of an object is given by the slope of the line joining the starting point and the end point of a certain interval of time.

$$\text{Slope of line} = \bar{v} = \frac{\Delta d}{\Delta t} = \frac{30 - 6}{5 - 2} = 8 \text{ m/s}$$

Which means that: The average velocity of the object from t = 2 s to t = 5 s is 8 m/s.

Notes :

(1) Instantaneous velocity equals average velocity during any time interval when the object moves by a uniform velocity in a straight line.

(2) The magnitude of the average velocity doesn't equal the average speed because the magnitude of the average velocity depends on the magnitude of the body's displacement while the average speed depends on the distance covered by the body and they aren't equal unless the body moves in a straight line in one direction.

Enrichment information

The fastest bird is the peregrine falcon where its speed reaches 107.5 m/s.

The fastest animal is the cheetah where its speed reaches 36.11 m/s.

The fastest fish is the sailfish where its speed reaches 30.28 m/s.

The fastest sprinter is Usain Bolt where his speed reaches 9.58 m/s.

Example 1

A person drove a car in a straight line to cover 8.4 km in 0.12 h. When the fuel had run out, he left the car and walked 2 km along the same straight line to reach the nearest gas station after 0.5 h:

(i) The magnitude of his average velocity from starting his motion till the end of journey is ....

ⓐ 4 km/h ⓑ 16.77 km/h ⓒ 33.68 km/h ⓓ 70 km/h

(ii) If the person returns to his car in 0.6 h, so the magnitude of his average velocity from starting his motion till the end of the journey is ....

ⓐ 18.9 km/h ⓑ 12.6 km/h ⓒ 8.42 km/h ⓓ 6.89 km/h

Solution

(i)

Average velocity $(\bar{v}) = \dfrac{\text{Total displacement (d)}}{\text{Total time (t)}}$

$$\bar{v} = \frac{d}{t} = \frac{8.4 + 2}{0.12 + 0.5} = 16.77 \text{ km/h}$$

∴ **The correct choice is ⓑ.**

(ii)

When the person returns back to the car, his total displacement = 8.4 km

$$v = \frac{d}{t} = \frac{8.4}{0.12 + 0.5 + 0.6} = 6.89 \text{ km/h}$$

∴ **The correct choice is ⓓ.**

Example 2

A body moves in a straight line to cover distance x with average velocity v and then it covers distance 4 x with average velocity 2 v, so its total average velocity equals ....

ⓐ v ⓑ $\frac{3}{2}$ v ⓒ $\frac{5}{4}$ v ⓓ $\frac{5}{3}$ v

Solution

Clue

To calculate the total average velocity of a body, we calculate the time of the body's motion during each interval.

$\because \bar{v} = \frac{d}{t}$

- The time of the first interval of motion:

$$t_1 = \frac{d_1}{v_1} = \frac{x}{v}$$

- The time of the second interval of motion:

$$t_2 = \frac{d_2}{v_2} = \frac{4x}{2v} = \frac{2x}{v}$$

- The total average velocity of the body's motion:

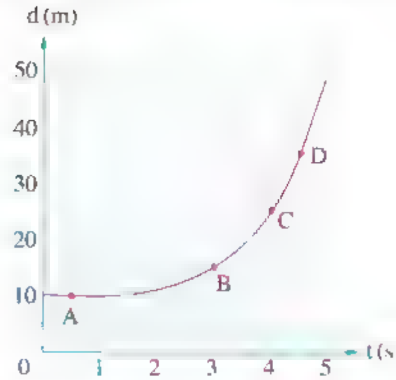
$$\bar{v} = \frac{d_1 + d_2}{t_1 + t_2} = \frac{x + 4x}{\frac{x}{v} + \frac{2x}{v}} = \frac{5}{3} v$$

∴ **The correct choice is ⓓ.**

What if the body moves in a constant direction with uniform velocity v for interval of time t then it moves with uniform velocity 2 v for interval of time 4 t, **so what** will be its total average velocity in terms of v?

Example 3

The opposite graph shows the relation between the displacement of a body moving in a straight line and time, then:



(i) The average velocity of the body through the interval from 1 s to 5 s equals ....

ⓐ 2.5 m/s ⓑ 5 m/s

ⓒ 7.5 m/s ⓓ 10 m/s

(ii) At which point in the graph, the instantaneous velocity is larger?

ⓐ A ⓑ B ⓒ C ⓓ D

(iii) At which point in the graph, the body is static?

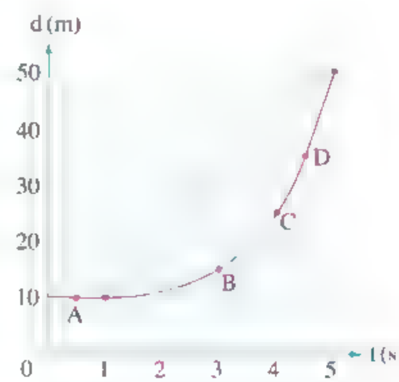
ⓐ A ⓑ B ⓒ C ⓓ D

Solution

(i)

Clue

To determine the average velocity of a body during a certain time interval from the (displacement-time) graph, we draw a straight line from the starting point of this interval to its end point and then we calculate the slope of this line.



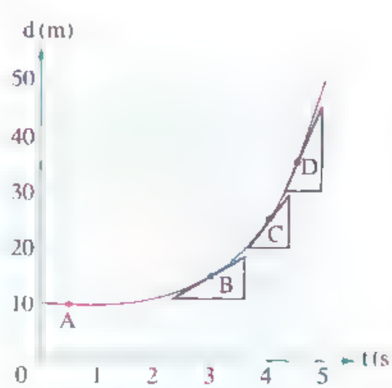
$$v = \frac{\Delta d}{\Delta t} = \frac{d_f - d_i}{t_f - t_i} = \frac{50 - 10}{5 - 1} = 10 \text{ m/s}$$

∴ **The correct choice is ⓓ.**

(ii)

Clue

The instantaneous velocity at a point is determined by the slope of the tangent at this point and as the tangent becomes steeper the instantaneous velocity becomes larger.



At point D, the instantaneous velocity is higher.

∴ **The correct choice is ⓓ.**

(iii)

Clue

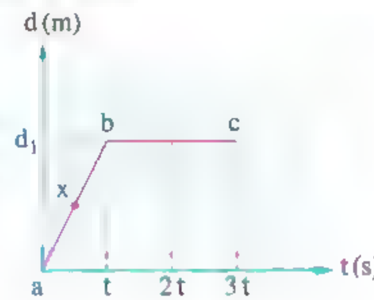
The body becomes static when its displacement doesn't change with time, which means that the body's motion is represented by a straight line parallel to the x-axis (the tangent's slope of the (displacement-time) curve vanishes).

At point A, the body is static. ∴ The correct choice is a .

What if you are asked to determine the points at which the velocity of the body is negative, **what** will be your answer?

Example 4

The opposite graph represents the relation between the displacement of a body that moves in a straight line (d) and the time (t). If the average velocity of the body during the interval abc is 4 m/s, then its instantaneous velocity at point x is ....



ⓐ 4 m/s ⓑ 8 m/s

ⓒ 12 m/s ⓓ 16 m/s

Solution

- The average velocity from a to c: $\bar{v} = \frac{d}{t}$, $4 = \frac{d_1}{3t}$

$\frac{d_1}{t} = 12$ m/s

- The instantaneous velocity at point x = The average velocity between the two points a, b

= The uniform velocity of the body between the two points a, b

$v = \text{Slope} = \frac{\Delta d}{\Delta t} = \frac{d_1}{t} = 12$ m/s

∴ The correct choice is ⓒ.

What if you are asked to determine the velocity of the body during the interval bc, **what** will be your answer?

Example 5

A body moves along the circumference of a circular path that has a radius r. When the body makes half a cycle, the ratio between its average velocity and its average speed is ....

ⓐ $\frac{\pi}{2}$ ⓑ 2π ⓒ $\frac{2}{\pi}$ ⓓ $\frac{2\sqrt{2}}{3\pi}$

Solution

- When the body moves half a cycle, then: $s = \pi r$, $d = 2r$

$\because \bar{v}_{speed} = \frac{s}{t}$, $\bar{v} = \frac{d}{t}$

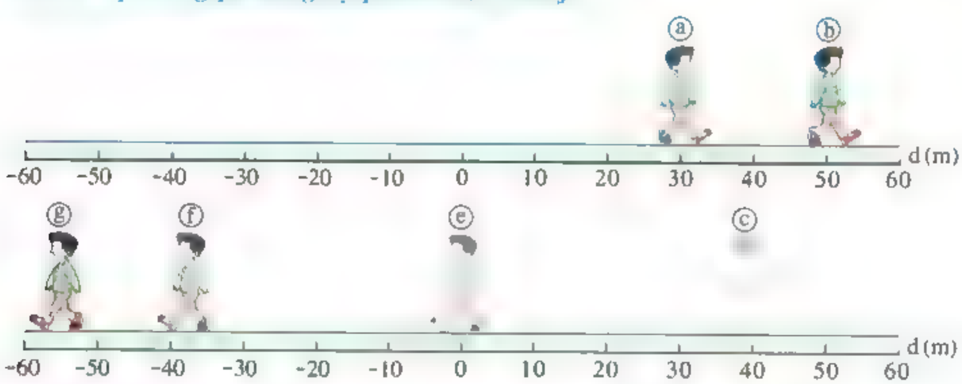
$\therefore \frac{\bar{v}}{\bar{v}_{speed}} = \frac{d}{t} \times \frac{t}{s} = \frac{d}{s} = \frac{2r}{\pi r} = \frac{2}{\pi}$

$\therefore$ **The correct choice is ⓒ.**

What if the body makes $\frac{3}{4}$ cycle, **what** will the ratio $\frac{\bar{v}}{\bar{v}_{speed}}$ be?

Example 6

The following figure shows a man who moves from point a to point b, then returns back until he reaches point g passing by points c, e and f.



The opposite table shows the position (x) of the man at each point and the time (t) taken to reach that point, then:

Point	t (s)	x (m)
a	0	30
b	10	52
c	20	38
e	30	0
f	40	– 37
g	50	– 53

(i) The total displacement of the man is ....

ⓐ – 53 m ⓑ 53 m

ⓒ 83 m ⓓ – 83 m

(ii) The total average velocity is ....

ⓐ 1.06 m/s ⓑ –1.06 m/s ⓒ 1.66 m/s ⓓ – 1.66 m/s

(iii) The total average speed is ....

ⓐ 0.42 m/s ⓑ 1.62 m/s ⓒ 2.54 m/s ⓓ 3.74 m/s

Solution

(i)

Clue

The man starts his motion from point a (+ 30 m) and ends his motion at point g (– 53 m), which means that his displacement is in the negative direction.

$$\Delta d = x_g - x_a$$

$$= -53 - 30 = -83 \text{ m}$$

∴ **The correct choice is ⓓ.**

(ii) $v = \frac{\Delta d}{\Delta t} = \frac{x_g - x_a}{t_g - t_a} = \frac{83}{50 - 0} = 1.66 \text{ m/s}$

∴ The correct choice is ⓓ.

(iii)

Clue

The man moves from point a to point b to cover distance s_{ab}, then he returns from point b to point g to cover distance s_{bg}

$$s_t = s_{ab} + s_{bg}$$

$$= (52 - 30) + \big(52 - (-53)\big) = 127 \text{ m}$$

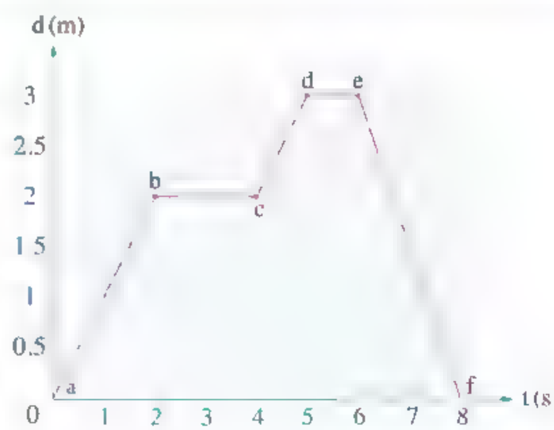
$$\therefore \bar{v}_{speed} = \frac{s_t}{t_g - t_a} = \frac{127}{50 - 0} = 2.54 \text{ m/s}$$

∴ The correct choice is [illegible]

What if you are asked to determine the interval (ab - bc - ce - ef - fg) in which the man has his largest average velocity, **what** will be your answer?

Example 7

The opposite (displacement-time) graph represents the motion of a girl in a straight line starting from her home until she returns back. Study the diagram, then find:



(a) The time intervals in which the girl has stopped.

(b) The greatest velocity at which the girl has moved.

(c) Why has the velocity become negative when the girl was returning back.

(d) The displacement and the total distance covered by the girl.

(e) The average velocity and the average speed of the girl.

Solution

(a)

Clue

The time intervals at which the girl has stopped are the intervals at which the displacement of the girl doesn't change with time.

The girl has stopped at the intervals: **bc** and **de**

(b)

Clue

The velocity of the girl is determined from the slope of the straight line that represents the (displacement-time) relation.

$$v_{ab} = \frac{2-0}{2-0} = \frac{2}{2} = 1 \text{ m/s}$$

$$v_{bc} = 0$$

$$v_{cd} = \frac{3-2}{5-4} = \frac{1}{1} = 1 \text{ m/s} \qquad v_{de} = 0$$

$$v_{ef} = \frac{0-3}{8-6} = \frac{-3}{2} = -1.5 \text{ m/s}$$

$\therefore$ The greatest velocity at which the girl has moved = 1.5 m/s

(c) The velocity became negative when the girl was returning back because she was moving in the opposite direction where the slope of the (displacement-time) curve through the interval ef is negative.

(d) $d = 0$, $s = 2 + 1 + 3 = 6$ m

(e) **The average velocity** $= \frac{\text{Total displacement}}{\text{Total time}} = \text{zero}$

The average speed $= \frac{\text{Total distance}}{\text{Total time}} = \frac{6}{8} = 0.75$ m/s

3 Test yourself

Answered

1 Choose the correct answer :

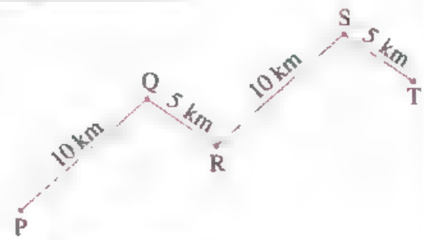
(1) A car was moving in a straight line, it covered 100 km in two hours. If the maximum velocity reached by the car during this journey was 90 km/h and the minimum velocity was 30 km/h, then its average velocity is ....

a) 30 km/h   b) 50 km/h   c) 60 km/h   d) 90 km/h

(2) A body starts its motion from rest in a straight line and moves with velocity of 2 m/s for 4 s, then it moves along the same straight line with velocity 4 m/s for 8 s. So, the magnitude of its average velocity during the 12 s is ……… .

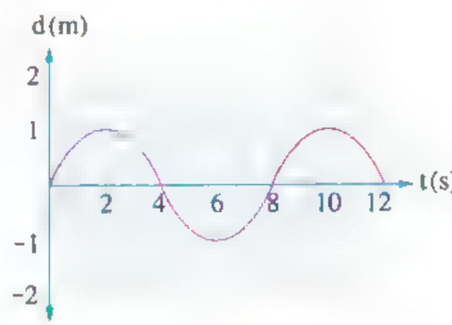
ⓐ $\frac{1}{2}$ m/s ⓑ $\frac{10}{3}$ m/s ⓒ 2 m/s ⓓ 10 m/s

2 The opposite figure shows the path of a moving car. If the car covered this path in half an hour, **calculate** its average speed during this interval.



…………………………………………………………………

3 The opposite graph describes the relation between the displacement (d) of a moving body and the time (t), **so at which** instants will the body's instantaneous velocity equal zero?



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…………………………………………………………………

Practical Experiment

Determining the velocity of a moving object

1. Experiment Objectives:

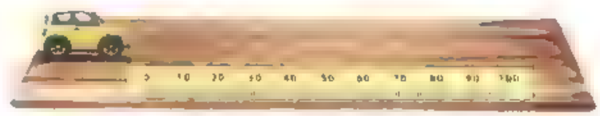
- Observing the relation between the displacement of a toy car that is moving beside a ruler and the time of motion.
- Drawing the (displacement-time) graph for the motion of the car and calculating its speed from the graph.

2. Tools:

1. Electric car toy. **2.** A meter ruler. **3.** A digital camera.

3. Procedure:

1. Fix a metric ruler aside the path in which the car would pass.
2. Mount the camera facing the toy and the ruler and turn it on.
3. Place the car at the start line and allow it to move in a straight line parallel to the ruler.



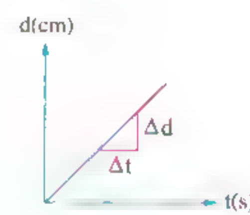
4. Determine the car position every 5 seconds by reading the metric ruler on the video display.
5. Record the results in a table as the following:

t (s)	0	5	10	15	20
d (cm)	....	....	....	....	....

6. Plot a graphical relationship between time (t) on the horizontal axis and displacement (d) on the vertical axis.

4. Conclusion:

When plotting the graphical relationship between displacement and time, a straight line is obtained that passes through the origin and its slope equals the velocity of the car (v).



The slope of the line $= \frac{\Delta d}{\Delta t} = v$

Chapter 1

Questions on Lesson One

Motion and Velocity

To watch videos of how to solve questions use the App

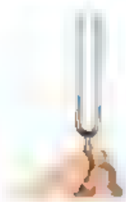
GPS

Interactive test

The questions signed by ✳ are answered in detail.

Multiple choice questions

1. Which of the following is considered a translational motion?


(a)


(b)


(c)

2. A leopard was chasing a prey, if it moved in a straight line by a uniform velocity of 10 m/s during 15 s, then its displacement is ....

(a) 25 m (b) 150 m (c) 1.5 m (d) 200 m

3. ✳ A car was moving in a straight road to Hurghada so that it passed by the (170 km) sign at 8:00 am and by the (5 km) sign at 10:00 am, so the average velocity by which the car was moving equals ....

(a) 64.96 m/s (b) 43.8 m/s (c) 32.4 m/s (d) 22.9 m/s

4. ✳ If the distance between the Sun and the Earth is 1496×10^5 km and the speed of light in the space is 3×10^5 km/s, so the time required for the sunlight to reach the Earth equals ....

(a) 498.67×10^3 s (b) 997.33 s (c) 498.67 s (d) 249.33 s

5. If a car is moving in a straight line to cover a distance of 300 m in a minute, the car's average speed is ....

(a) 300 m/s (b) 260 m/s (c) 240 m/s (d) 5 m/s

6. ✳ A student was participating in the annual race of the school, the race is of distance 6 km. The student wishes to break the record of the fastest competitor which is 26 minutes. The race begins and ends down the clock tower of the school, if the race begins when the clock tower is as in figure (1) and ends when the clock tower is as in figure (2):


Figure (1)


Figure (2)

(i) Does the student break the record?

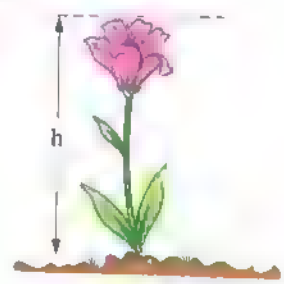
ⓐ Yes, by 10 minutes. ⓑ Yes, by 5 minutes.

ⓒ Yes, by 1 minute. ⓓ No.

(ii) The average speed of the student during the race equals ....

ⓐ 0.24 m/s ⓑ 2 m/s ⓒ 4 m/s ⓓ 4.2 m/s

7 ✻ A botanist studies the growth of one of his plants by measuring the length (h) of the plant everyday at the same time and the next table shows his results:

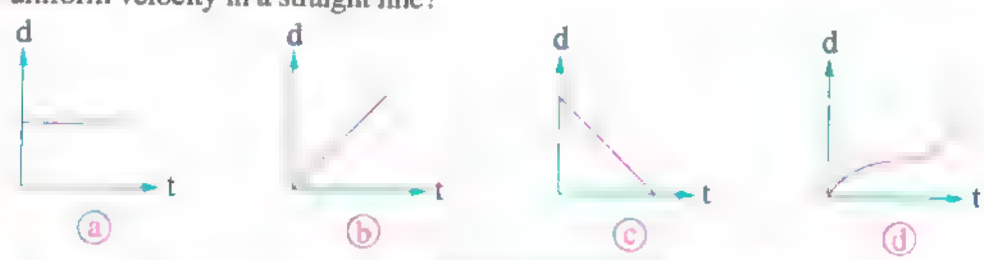


t (days)	0	1	2	3	4	5	6	7
h (cm)	2.1	6.5	11.4	18.4	24.5	26.7	30.7	37.1

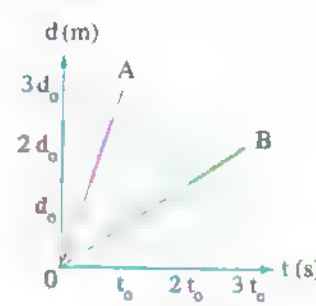
So, the average speed of the plant's growth during 7 days equals ....

5.3 cm/day 5 cm/day 4.92 cm/day 4.76 cm/day

8 Which of the following graphs of displacement versus time describes a body moving with non-uniform velocity in a straight line?



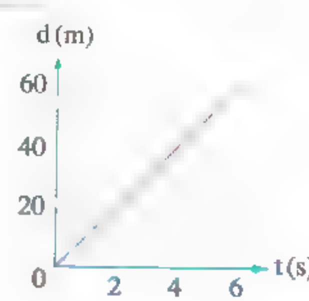
9 ✻ The opposite graph represents the relation between the displacement (d) and time (t) of two bodies A and B that are moving in a straight line, so the ratio between their velocities $\left(\frac{v_A}{v_B}\right)$ equals ....



ⓐ $\frac{9}{2}$ ⓑ $\frac{9}{4}$

ⓒ $\frac{3}{2}$ ⓓ $\frac{4}{3}$

10 ✻ The opposite graph of displacement (d) versus time (t) describes the motion of a body which is moving with a ....



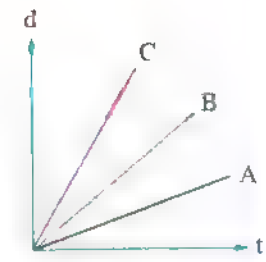
ⓐ non-uniform velocity whose average is 10 m/s

ⓑ non-uniform velocity whose average is 40 m/s

ⓒ uniform velocity of 10 m/s

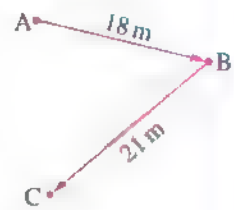
ⓓ uniform velocity of 40 m/s

11 * The opposite graph represents the relation between the displacement (d) and time (t) of three students A, B and C that move in straight lines, then ....



(a) the velocity of A > the velocity of B > the velocity of C
(b) the velocity of C > the velocity of B > the velocity of A
(c) the velocity of B > the velocity of C > the velocity of A
(d) the velocity of C = the velocity of B = the velocity of A

12 * The opposite figure shows the path of a football that was kicked between three players on a playground, if the ball moves from player A to player B in 1.2 s, then:



(i) The magnitude of the average velocity of the ball between A and B equals ....

(a) 25.2 m/s (b) 21.6 m/s (c) 17.5 m/s (d) 15 m/s

(ii) The time required for the ball to move from B to C with the same magnitude of the average velocity that was calculated in (i) equals ....

(a) 1.4 s (b) 1.2 s (c) 0.83 s (d) 0.71 s

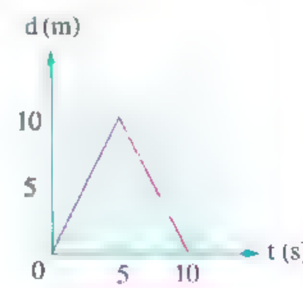
13 A man is running in a rectangular path of dimensions 50 m and 40 m. If he completes one revolution in a time of 100 s, then his average velocity equals ....

(a) 9 m/s (b) 1.8 m/s (c) 0.9 m/s (d) 0

14 * The Earth orbits the Sun in a roughly circular path to complete one revolution around the Sun in 365.25 days, if the average of the radius of the Earth's orbit is 1.5×10^{11} m, then its average speed around the Sun during one complete revolution equals ....

(a) 90.1 km/s (b) 29.9 km/s (c) 15.2 km/s (d) 300 m/s

15 * The opposite graph represents the change of the displacement of a body that moves in a straight line versus time, then:



(i) The total distance covered by the body equals ....

(a) 20 m (b) 15 m
(c) 10 m (d) 5 m

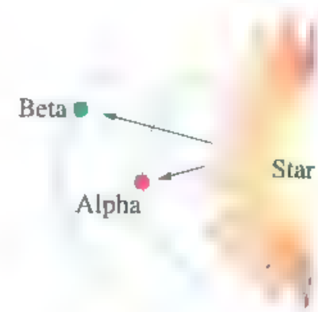
(ii) The total displacement of the body equals ....

(a) 10 m (b) 7.5 m (c) 5 m (d) 0

(iii) The velocity of the body in the first five seconds equals ....

(a) 4 m/s (b) 3 m/s (c) 2 m/s (d) 1 m/s

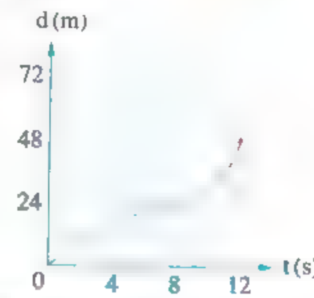
16 ✳ In the opposite figure, light travels from the star to planet Alpha in fifteen minutes and travels from the star to planet Beta in one hour. If the speed of light in the space is 3×10^8 m/s, then the distance between the orbits of the two planets equals ....



ⓐ 81×10^{20} m ⓑ 81×10^{10} m

ⓒ 48×10^{8} m ⓓ 48×10^{11} m

17 ✳ The opposite graph shows a part of the journey of a car which is moving in a straight road at a certain direction, what is the average velocity of the car during the shown 12 s?



ⓐ 5 m/s ⓑ 4 m/s

ⓒ 2.5 m/s ⓓ 2 m/s

18 If a body moves on a curved path, the ratio between the average speed of the body during a certain time interval and its average velocity during the same interval will be ....

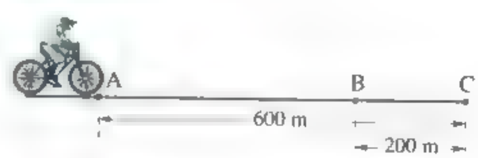
ⓐ greater than one

ⓑ less than one

ⓒ equal to one

ⓓ we can't determine the answer, unless we know the time of motion

19 ✳ The opposite figure shows a bike that starts its motion from rest at point A to reach point C after 80 s, then it returns back in the opposite direction to reach point B after 20 s, so the magnitude of the average velocity of the bike in each of the following intervals is ....



	From t = 0 to t = 80 s	Through the whole journey
ⓐ	8 m/s	8 m/s
ⓑ	8 m/s	4 m/s
ⓒ	7.5 m/s	8 m/s
ⓓ	7.5 m/s	4 m/s

20 ✱ If a car covered 30 km in the south direction during 0.5 h, then it covered 40 km in the east direction during 2.5 h, so:

(i) The magnitude of the average velocity of the car equals ....

ⓐ 8.24 km/h ⓑ 12.54 km/h

ⓒ 16.67 km/h ⓓ 18.22 km/h

(ii) The average speed of the car equals ....

ⓐ 16.67 km/h ⓑ 23.33 km/h

ⓒ 25.21 km/h ⓓ 27.42 km/h

21 ✱ In a football match, the ball was 50 m away from a player who was running towards it at uniform velocity of 3 m/s, meanwhile another player was at 35 m from the ball and ran at uniform velocity of 2 m/s towards the ball, so the first player reaches the ball ....

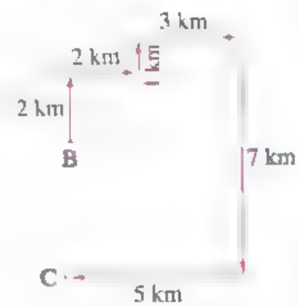
ⓐ before the second player by a time of 0.83 s

ⓑ before the second player by a time of 0.55 s

ⓒ after the second player by a time of 0.83 s

ⓓ after the second player by a time of 0.55 s

22 ✱ The opposite figure shows the path of a body that starts its motion from point B and takes 4 h to cover the shown path, then:



(i) The average velocity of the body equals ....

ⓐ 1.25 km/h in the north direction

ⓑ 1.25 km/h in the south direction

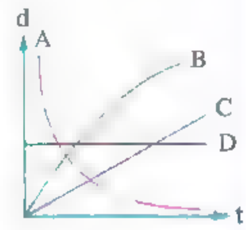
ⓒ 1 km/h in the north direction

ⓓ 1 km/h in the south direction

(ii) The average speed of the body equals ....

ⓐ 1 km/h ⓑ 4.25 km/h ⓒ 4.75 km/h ⓓ 5 km/h

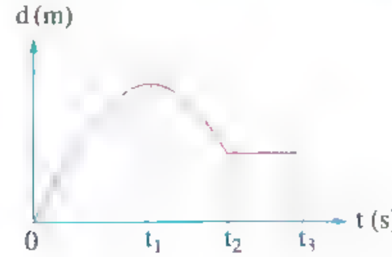
23 The opposite graph describes the displacement (d) of four students (A, B, C, D) relative to their school with respect to time (t), so which student was initially moving fast towards the school then slowed down?



ⓐ Student A ⓑ Student B

ⓒ Student C ⓓ Student D

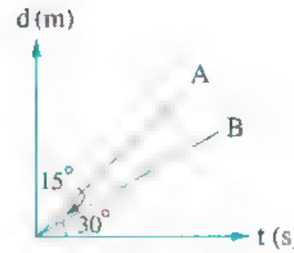
24 ✳ The opposite (displacement-time) graph represents the motion of a body in a straight line, hence the time interval at which the velocity is negative is between ....



0, t_1 t_1, t_2

ⓒ t_2, t_3 ⓓ t_1, t_3

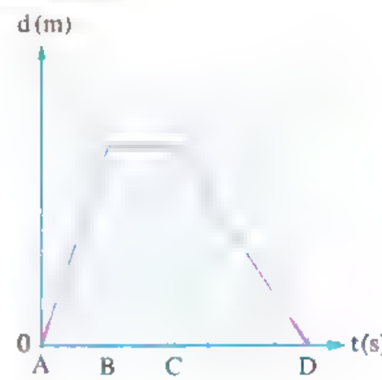
25 ✳ The opposite graph shows the relation between the displacement and time for two bodies A and B that start their motion from rest in a straight line, so the ratio between their velocities $\left(\frac{v_A}{v_B}\right)$ is ....



ⓐ 0.46   ⓑ 2.15

ⓒ $\sqrt{3}$ ⓓ $\sqrt{2}$

26 ✳ The opposite (displacement-time) graph represents the motion of a girl that rides a bicycle on a straight road, then:



(i) The velocity of the girl during the interval AB is ....

ⓐ positive and uniform

ⓑ negative and uniform

ⓒ non-uniform

ⓓ equal to zero

(ii) The velocity of the girl during the interval BC is ....

ⓐ positive and uniform

ⓑ negative and uniform

ⓒ non-uniform

ⓓ equal to zero

(iii) The velocity of the girl during the interval CD is ....

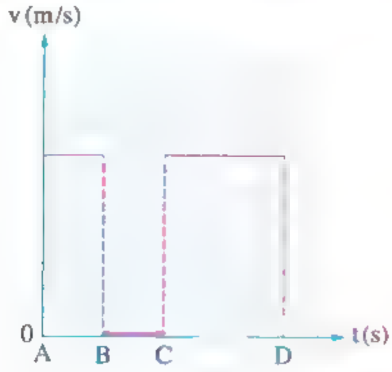
ⓐ positive and uniform

ⓑ negative and uniform

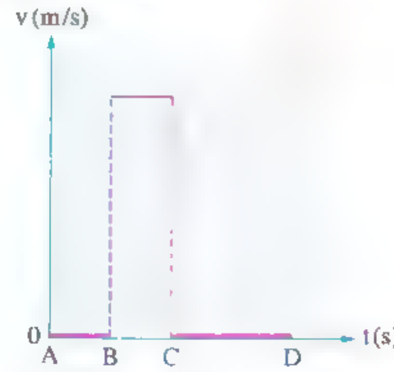
ⓒ non-uniform

ⓓ equal to zero

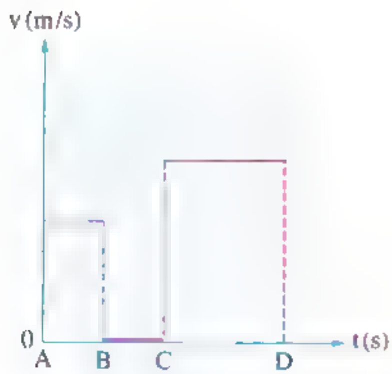
(iv) Which of the following graphs represents the relation between the magnitude of the girl's velocity during the intervals AB, BC and CD with the time?



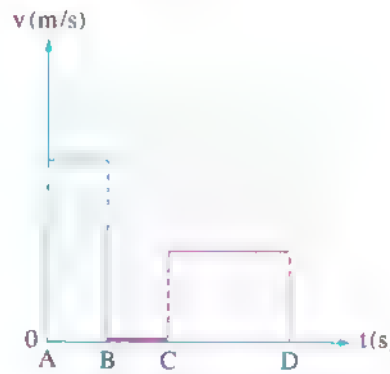
ⓐ



ⓑ

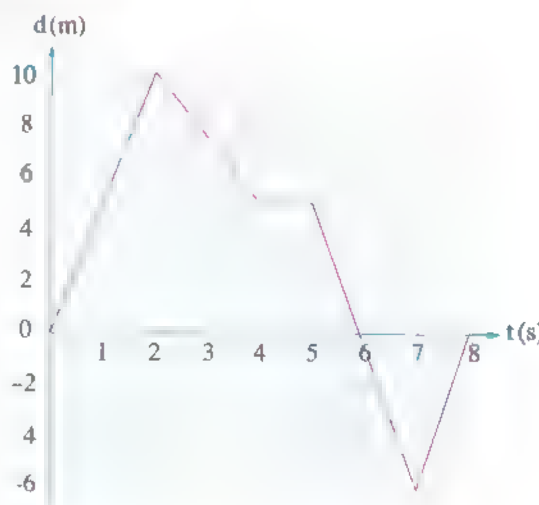


ⓒ



ⓓ

27 ✳ The opposite graph represents the change of the displacement of a body that moves in a straight line versus the time, then:



(i) The average velocity of the body during the following intervals:

① from t = 0 to t = 2 s equals ....

ⓐ 5 m/s ⓑ 4 m/s

ⓒ 3 m/s ⓓ 2 m/s

② from t = 0 to t = 4 s equals ....

ⓐ 1.5 m/s ⓑ 1.25 m/s

ⓒ 0.75 m/s ⓓ 0.5 m/s

③ from t = 4 s to t = 7 s equals ....

ⓐ – 3 m/s ⓑ 3.33 m/s ⓒ – 3.67 m/s ⓓ 4.33 m/s

④ from $t = 0$ to $t = 8$ s equals ....

ⓐ 0.5 m/s ⓑ 0.75 m/s ⓒ – 0.25 m/s ⓓ 0

(ii) The instantaneous velocity of the body at:

① $t = 1$ s equals ....

ⓐ 1 m/s ⓑ 2 m/s ⓒ 3 m/s ⓓ 5 m/s

② $t = 3$ s equals ....

ⓐ – 2.5 m/s ⓑ – 5 m/s ⓒ 2.5 m/s ⓓ 5 m/s

③ $t = 4.5$ s equals ....

ⓐ 2 m/s ⓑ 1 m/s ⓒ 0 ⓓ – 0.5 m/s

④ $t = 7.5$ s equals ....

ⓐ 3 m/s ⓑ 6 m/s ⓒ – 3 m/s ⓓ – 6 m/s

28 ✳ A body moves along a straight line at velocity v to cover a distance d, then it moves in the same direction at velocity 2 v to cover a distance 4 d, so its total average velocity equals ....

ⓐ v ⓑ $\frac{3}{2}$ v ⓒ 2 v ⓓ $\frac{5}{3}$ v

29 ✳ A car is moving in a straight road for time t by an average velocity v, then it moves for time 2 t by an average velocity 2 v, so its total average velocity is ....

ⓐ v ⓑ 2 v ⓒ $\frac{3}{2}$ v ⓓ $\frac{5}{3}$ v

30 ✳ A car was moving in a straight road of length 320 km, it covered 240 km with an average velocity of 75 km/h, then it ran out of fuel and stopped for 0.6 h until it was refueled and completed its journey with a velocity of 100 km/h until it reaches the end of the journey. So, the average velocity of the car during the whole journey was ....

ⓐ 69.57 km/h ⓑ 80 km/h ⓒ 87.57 km/h ⓓ 95 km/h

31 ✳ A girl is running in a straight line with a constant velocity of 5 m/s from point A to point B, then she returns back in a straight line from point B to point A with a constant velocity of 3 m/s, so:

(i) The average speed during the whole journey equals ....

ⓐ 3.75 m/s ⓑ 1.875 m/s ⓒ 0.533 m/s ⓓ 0

(ii) The magnitude of the average velocity during the whole journey equals ....

ⓐ 3.75 m/s ⓑ 0.26 m/s ⓒ 0.13 m/s ⓓ 0

32 ✳ A body moves in a straight line with a velocity of 10 m/s for a distance of 100 m then it moves a distance of 100 m with a velocity of 20 m/s, so the average velocity of the body equals ....

(a) 6.66 m/s (b) 10 m/s (c) 12.5 m/s (d) 13.33 m/s

33 ✳ A body moves in a straight line for one minute with a velocity of 10 m/s then it moves for another minute with a velocity of 20 m/s, so the average velocity of the body equals ....

(a) 15 m/s (b) 13 m/s (c) 7.5 m/s (d) 5 m/s

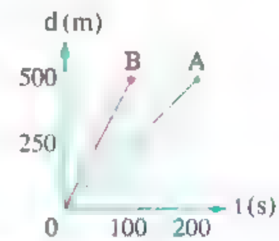
Essay questions

1. If the average velocity of a body during a certain time interval equals zero. **What** can you deduce about the displacement of the body during this interval?

2. In the opposite figure:

Two objects (A) and (B) have moved from rest in a straight line.

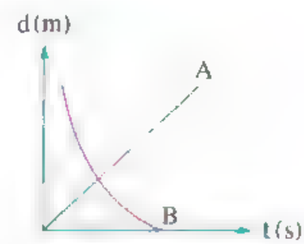
Which object has been faster? **And why**?



3. The opposite graph represents the change in displacement of two objects (A) and (B) relative to a building with time.

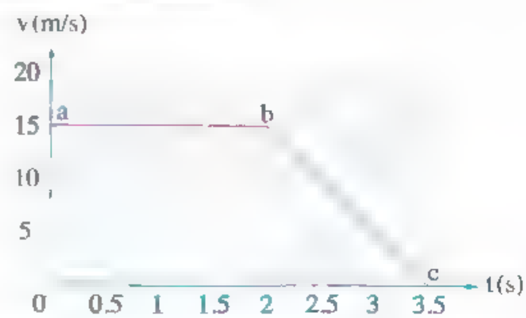
(a) **Which of them** is moving away from the building **and which** is getting closer to the building?

(b) **Which of them** is moving at uniform velocity **and which** is moving at non-uniform velocity? **Explain your answer.**



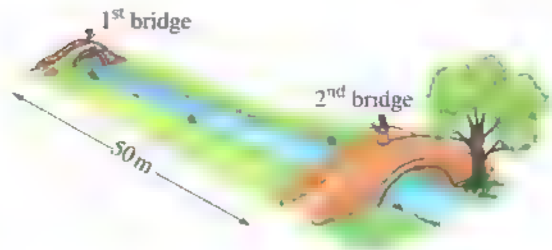
4. A car was moving in a straight road, at t = 0 the driver saw a barrier on the road, so he pressed the brakes. The opposite graph represents the relation between the velocity of the car and the time:

(a) **Describe** the velocity of the car during the intervals ab and bc.



(b) **Calculate** the displacement covered by the car from t = 0 to t = 3.5 s.

5 The opposite figure shows two girls trying to measure the speed of the river's water stream. The girl who stands on the first bridge drops a piece of wood in the water and the girl who stands on the second bridge measures the time (t) taken by the piece of wood to reach the second bridge:



(a) **Mention** the suitable tools that can be used by the girls to measure the distance between the two bridges and also the time (t).

(b) If the time taken by the wooden piece to cover the distance between the two bridges is 400 s, **calculate** the speed of the river's water stream.

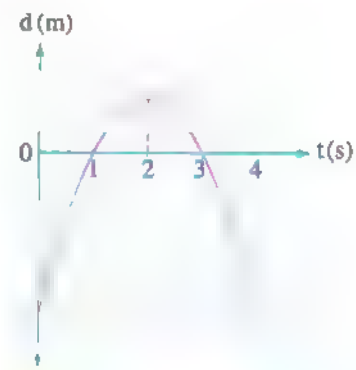
6 The opposite (displacement-time) graph describes the motion of a body in a straight line.

Is the velocity of the body positive, negative or zero at:

(a) t = 1 s

(b) t = 2 s

(c) t = 3 s

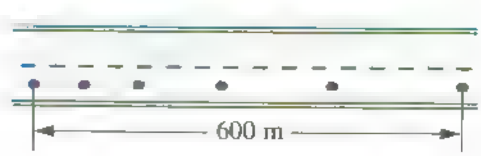


Questions that measure high levels of thinking

Answered in detail

Choose the correct answer:

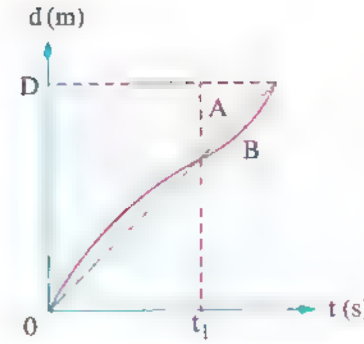
1 A car is moving in a straight horizontal road where its engine leaks an oil drop every 5 s on the road as shown in the opposite figure, then the average velocity of the car during the distance shown in the figure equals ....



ⓐ 120 m/s ⓑ 60 m/s

ⓒ 24 m/s ⓓ 12 m/s

2 The opposite graph shows the relation between the displacement (d) and the time (t) of two cars A and B that start a race of length D at $t = 0$ and move in a straight line. Which of the following statements is wrong?



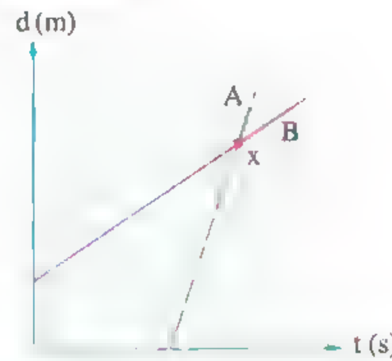
ⓐ Car A moves with a uniform velocity while car B moves with non-uniform velocity.

ⓑ Car A reaches the end of the race first.

ⓒ At time t_1, the average velocity of car A equals the average velocity of car B.

ⓓ The two cars cover the same displacement after time t_1

3 The opposite graph of displacement (d) versus time (t) describes the motion of two boys A and B moving at a uniform velocity in a straight line. Which of the following sentences is right?



ⓐ B starts his motion after A.

ⓑ The velocities of A and B are equal at point x.

ⓒ The velocity of A is less than that of B.

ⓓ A precedes B after passing point x.

4 If a car is moving in a straight road in one direction to cover one third of the distance at velocity of 25 km/h and the rest of the distance at velocity of 75 km/h, so the average velocity of the car is ....

ⓐ 30 km/h ⓑ 45 km/h ⓒ 50 km/h ⓓ 65 km/h

5 Two boys A and B were running in a straight line towards each other. If at a given instant they were at two points x, y respectively where the distance between them was 135 m, the velocity of boy A was 6.75 m/s and the velocity of boy B was 5.25 m/s, then when they meet, ...

	The distance between boy A and point (x)	The distance between boy B and point (y)
ⓐ	75.94 m	59.06 m
ⓑ	75.94 m	240 m
ⓒ	308.6 m	59.06 m
ⓓ	308.6 m	240 m

Chapter 1

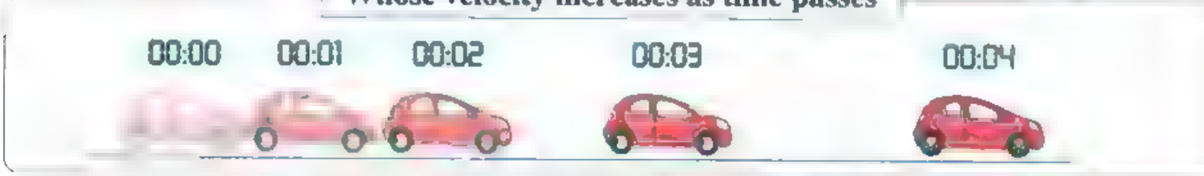
Lesson Two

Acceleration

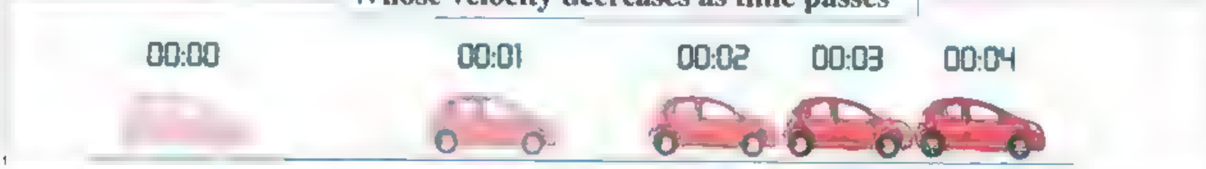
Why it's important for a racer to know the least interval of time that his car takes to reach 100 km/h from rest?

If the velocity of an object is changed from one point to another either in magnitude or in direction, this change in velocity with time (rate of change of velocity) is known as **acceleration** and such motion is called **accelerated motion**, for example the following figure represents the change of the position of a car:

Whose velocity increases as time passes



Whose velocity decreases as time passes



- The acceleration can be determined by the relation:

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time of change}} = \frac{\text{Final velocity} - \text{Initial velocity}}{\text{Final time} - \text{Initial time}}$$

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

- The unit of measuring acceleration is m/s^2 and its dimensional formula is LT^{-2}.

Types of acceleration

1 Uniform (constant) acceleration

- **It is** the acceleration in which the object changes its velocity with **equal amounts** in equal intervals of time.

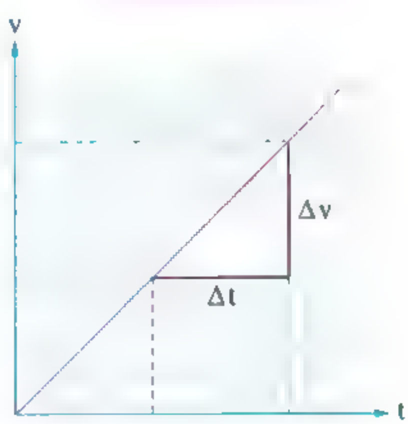
2 Non-uniform (variable) acceleration

- **It is** the acceleration in which the object changes its velocity with **unequal amounts** in equal intervals of time.

Graphical representation

When plotting the relation between velocity (v) on the ordinate (y-axis) and time (t) on the abscissa (x-axis) $\boxed{\text{(v-t) curve}}$, we get:

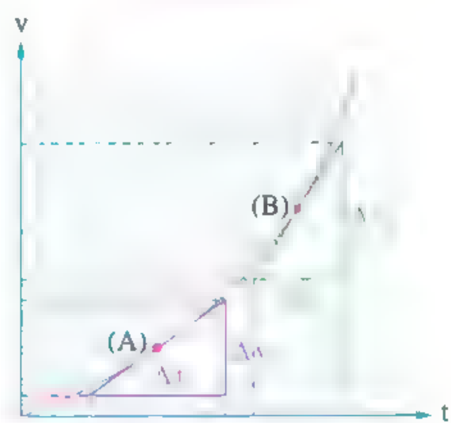
A straight line



- The slope of the straight line gives the uniform acceleration by which the object moves.

Slope of line $= a = \frac{\Delta v}{\Delta t}$

A curve



- The slope of the tangent drawn to the curve at any point gives the instantaneous acceleration of the object at this point.

Slope at (A) $= a_A = \frac{\Delta v_1}{\Delta t_1}$

Slope at (B) $= a_B = \frac{\Delta v_2}{\Delta t_2}$

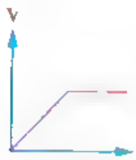
Integration with Mathematics

You can revise how to calculate the slope of a straight line from section (8) page (13).

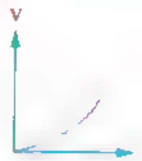
1 Test yourself

Answered

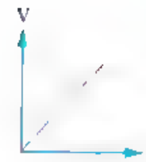
Choose from graphs (a, b, c) what suits the graphs (1, 2, 3):



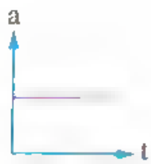
(1)



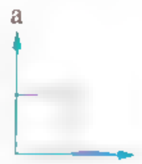
(2)



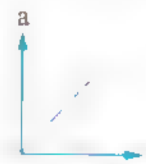
(3)



(a)



(b)



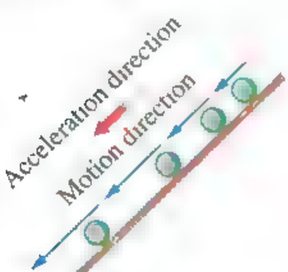
(c)

⊙ If we assume that the velocity of an object is positive, its acceleration may be:

1. Positive (increasing velocity).
2. Equal to zero (uniform velocity).
3. Negative and in this case it is called deceleration (decreasing velocity).

1 Positive acceleration

▶ It is the acceleration of the object when its velocity increases with time.

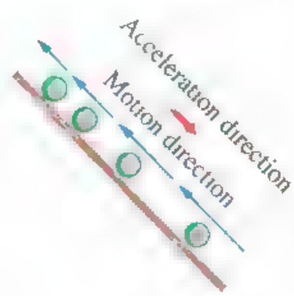


2 Zero acceleration

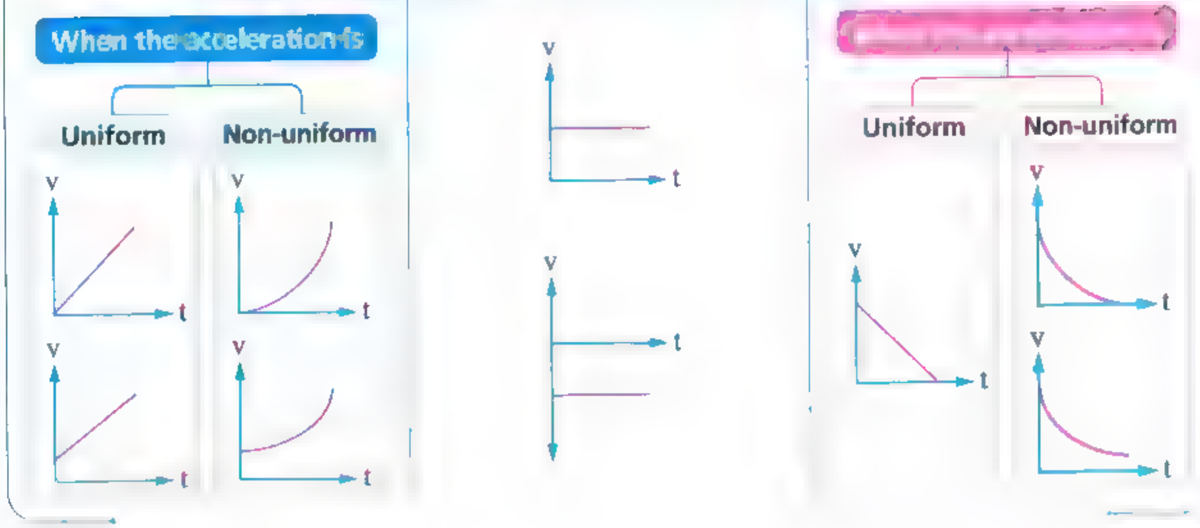
▶ It is the acceleration when the velocity of the object is uniform (constant) with time.

3 Negative acceleration

▶ It is the acceleration of the object when its velocity decreases with time.



Graphical representation for the (velocity-time) curve



Notes:

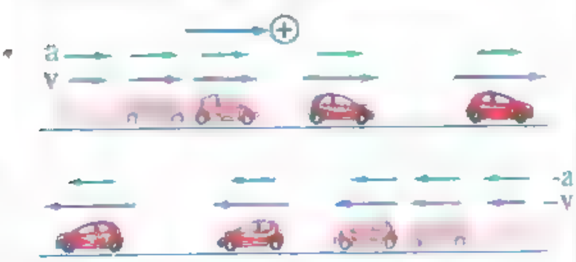
(1) If the object moves in a straight line with uniform acceleration, its average velocity through a given time interval is given from the relation: $\bar{v} = \frac{v_i + v_f}{2}$

(2) If the driver applies the brakes, the car moves with acceleration that has a direction opposite to the direction of motion, so it slows down until it stops.

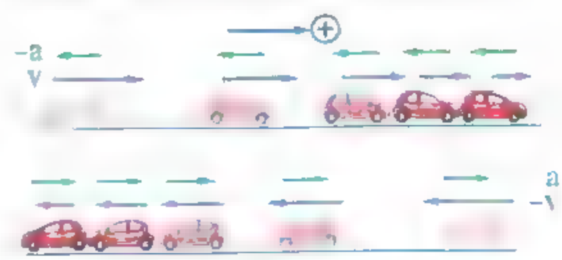
(3) When observing the motion of a body, a certain direction is assumed to be the positive direction of motion. If the direction of acceleration is the same as this direction, then the acceleration has positive sign and if the direction of acceleration is opposite to this direction, then the acceleration has negative sign,

so

If the velocity and the acceleration have the same direction (same sign), then the velocity of the body is increasing.



If the velocity and the acceleration have different directions (different signs), then the velocity of the body is decreasing.



Example 1

A car was moving at velocity 30 m/s. When the driver applied the brakes, the car moves with uniform acceleration till it stopped within 15 s, then the acceleration of the car equals ....

ⓐ 1 m/s² ⓑ 2 m/s² ⓒ – 1 m/s² ⓓ – 2 m/s²

Solution

Clue

The initial velocity is the velocity by which the car was moving directly before applying the brakes, so the initial velocity equals 30 m/s and the final velocity equals zero because the car comes to rest.

$v_i = 30$ m/s $v_f = 0$ $\Delta t = 15$ s $a = ?$

$\Delta v = v_f - v_i = 0 - 30 = -30$ m/s

$a = \frac{\Delta v}{\Delta t} = \frac{-30}{15} = -2 \text{ m/s}^2$

∴ **The correct choice is ⓓ.**

What if you are asked to calculate the average velocity of the car during 15 s from the moment of applying the brakes till it stopped, **what** will be your answer?

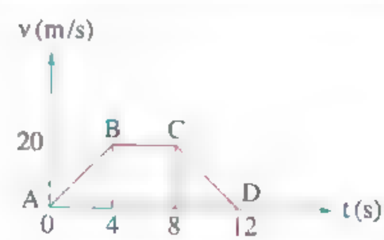
Example 2

From the opposite graph:

(*a*) **Describe** the type of motion by which the body moves within 12 s.

(*b*) **Calculate** the acceleration in each interval.

(*c*) **Calculate** the distance covered by the body during the interval BC.



Solution

Clue

The slope of the line in the (velocity-time) graph represents the body's acceleration. If the slope is positive, the acceleration is positive and if the slope is negative, the acceleration is negative and if the slope equals zero, the acceleration equals zero.

(*a*) - During the first 4 s the body is moving with a positive uniform acceleration.
- During the second 4 s the body is moving with a uniform velocity (zero acceleration).
- During the last 4 s the body is moving with a uniform deceleration (negative acceleration).

(b) - From A to B:

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{20 - 0}{4 - 0} = \frac{20}{4} = 5 \text{ m/s}^2$$

- From B to C:

$a = 0$

- From C to D:

$$a = \frac{\Delta v}{\Delta t} = \frac{0 - 20}{12 - 8} = \frac{-20}{4} = -5 \text{ m/s}^2$$

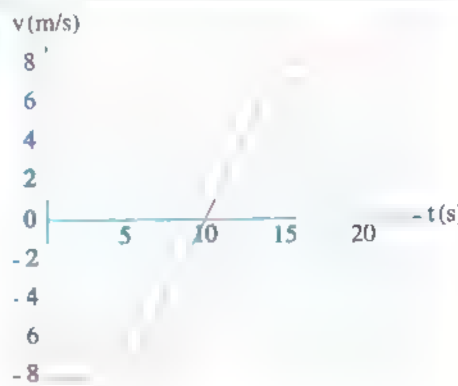
(c) s = The area under the curve during this interval = $v\Delta t$

$= 20 \times (8 - 4) = 80$ m

What if you are asked to determine the total distance covered by the body during the 12 s, **what** will be your answer?

Example 3

The opposite graph shows the relation between the velocity of a body that moves in a straight line and the time, then:

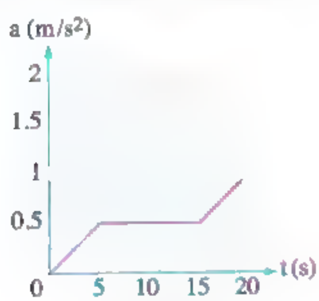


(i) The acceleration of the body from t = 5 s to t = 15 s equals ....

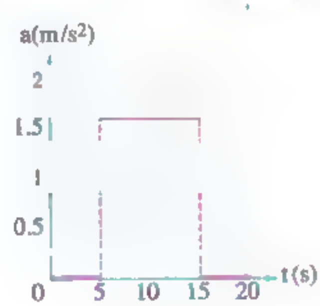
ⓐ 6.4 m/s^2 ⓑ 4.8 m/s^2

ⓒ 3.24 m/s^2 ⓓ 1.6 m/s^2

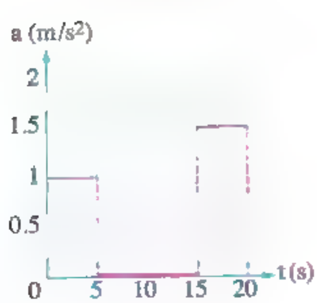
(ii) The (acceleration-time) graph that describes the motion of the body is ....



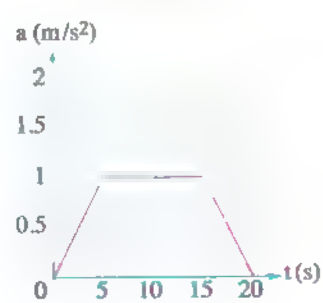
ⓐ



ⓑ



ⓒ



ⓓ

Solution

(i)

Clue

The acceleration of the body equals the slope of the (velocity-time) line.

$$a = \frac{\Delta v}{\Delta t} = \frac{8-(-8)}{15-5} = \frac{16}{10} = 1.6\ m/s^2$$

∴ The correct choice is d .

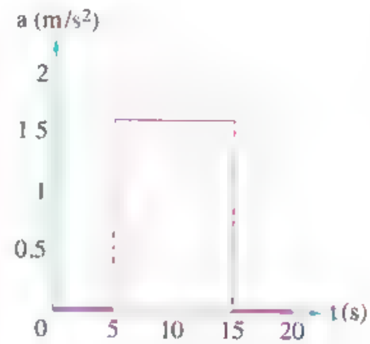
(ii)

Clue

To draw the (acceleration-time) graph for the moving body, we should calculate the slope of the (velocity-time) graph through the following time intervals:

- *From $t = 0$ to $t = 5$ s: a = Slope = 0*
- *From $t = 5$ s to $t = 15$ s: a = Slope = $1.6\ m/s^2$*
- *From $t = 15$ s to $t = 20$ s: a = Slope = 0*

Then we plot the results to get the opposite graph of acceleration versus time.



∴ The correct choice is ⓑ.

What if you are asked to calculate the total displacement of the body during 20 s, **what** will be your answer?

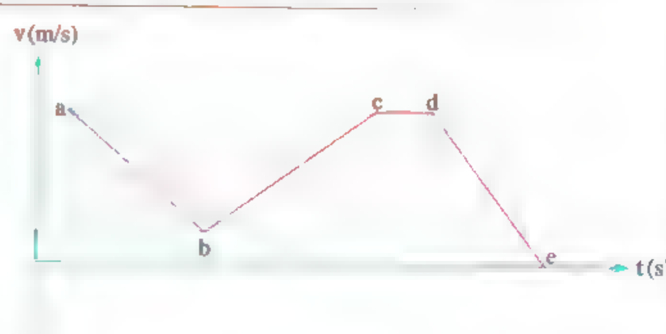
Test yourself

Answered

1 **Choose the correct answer:** If the lion can move with an acceleration of $9.5\ m/s^2$, then the time taken by the lion to move in a straight line from rest to reach a velocity of 4.5 m/s when it moves by this acceleration is ......

ⓐ 0.32 s ⓑ 0.47 s ⓒ 0.65 s ⓓ 0.84 s

2 The opposite graph shows the relation between the velocity of a body that moves in a straight line and the time, **then in which** time interval the body's acceleration is:



(1) positive?
(2) negative?
(3) zero?

....

....

Chapter 1

Questions on Lesson Two

Acceleration

To watch videos of how to solve questions use the App

GPS

Interactive test

The questions signed by ✳ are answered in detail.

● Analyze

First Multiple choice questions

1 If a body starts its motion from rest and moves by acceleration a to reach a velocity v_f after time t, so its final velocity v_f can be represented by the relation;

ⓐ $v_f = \frac{a}{t}$ ⓑ $v_f = at$ ⓒ $v_f = \frac{1}{2} at^2$ ⓓ $v_f = \sqrt{at}$

2 If the acceleration is represented by the relation; $a = \frac{\Delta v}{\Delta t}$, then the change in the velocity of a body that is moving by an acceleration of 4 m/s^2 during 2 s is ....

ⓐ 6 m/s ⓑ 8 m/s ⓒ 10 m/s ⓓ 12 m/s

3 A body is moving with a uniform velocity of 5 m/s for 5 s, then its acceleration equals ....

ⓐ 5 m/s^2 ⓑ 1 m/s^2 ⓒ zero ⓓ – 5 m/s^2

4 If an object starts motion from rest and speeds up at a constant rate till its velocity becomes 50 m/s during 10 s, this object moves at an acceleration of ... . . .

ⓐ $\frac{1}{5}$ m/s^2 ⓑ 5 m/s^2 ⓒ 40 m/s^2 ⓓ 60 m/s^2

5 ✳ When the brakes of a car that was moving at a velocity of 20 m/s were applied, the velocity of the car changed uniformly with time until it stopped and the opposite figure shows the position (x) of the car from the moment of applying the brakes until it stopped. If the direction of motion of the car is the positive direction of motion, then during this interval of motion . . .

t (s)	0	2	4	6	10
x (m)	0	36	64	84	100

	The average velocity of the car	The acceleration of the car
ⓐ	2 m/s	– 1 m/s^2
ⓑ	2 m/s	– 2 m/s^2
ⓒ	10 m/s	2 m/s^2
ⓓ	10 m/s	– 2 m/s^2

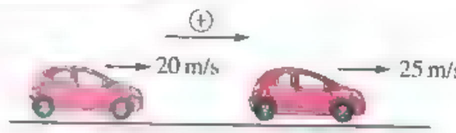
6 ✳ A man starts his motion from rest with uniform acceleration of 1 m/s^2, so his average velocity equals 1 m/s during . ... from starting his motion.

ⓐ 1 s ⓑ 2 s ⓒ 4 s ⓓ $\frac{1}{2}$ s

7 When a body moves to the north with a uniform acceleration in the north direction, so its ....

(a) initial velocity > its final velocity
(b) initial velocity < its final velocity
(c) initial velocity = its final velocity
(d) velocity has variable direction

8 In the opposite figure, the car moves by ....



(a) positive acceleration
(b) negative acceleration
(c) uniform velocity
(d) decreasing velocity

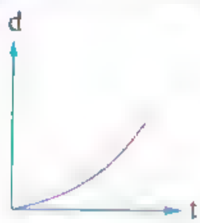
9 When the object's acceleration is in the opposite direction to its velocity, its ....

(a) instantaneous velocity always equals its average velocity
(b) velocity increases with time
(c) velocity decreases with time
(d) velocity doesn't change with time

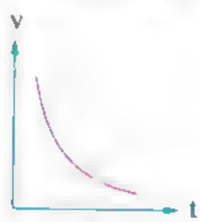
10 If both the directions of velocity and acceleration are negative, ...

(a) the velocity of the object increases
(b) the velocity of the object decreases
(c) the velocity of object is constant
(d) the object stops

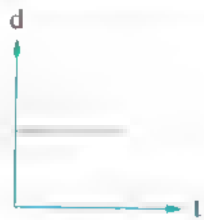
11 The following graphs describe a body moving with an acceleration except ....



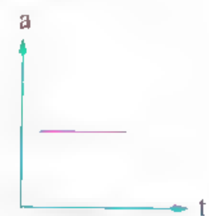
(a)



(b)

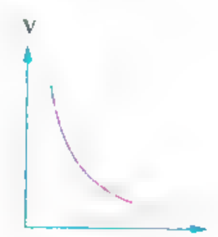


(c)



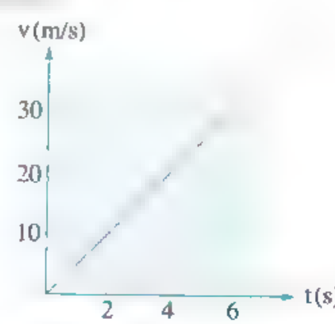
(d)

12 The opposite graph represents the relation between the velocity (v) and the time (t) of a car moving with .... acceleration.



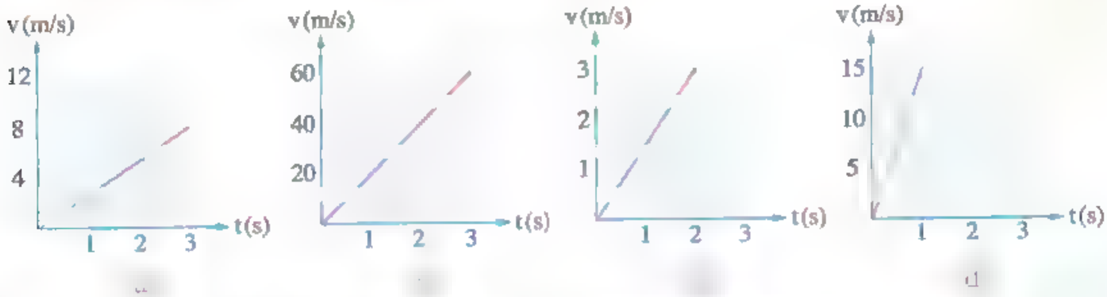
(a) positive uniform
(b) negative non-uniform
(c) negative uniform
(d) positive non-uniform

13 ✳ The opposite graph shows the relation between the body's velocity (v) and the time (t), then the body moves by ....



(a) uniform acceleration of 10 m/s^2
(b) uniform acceleration of – 5 m/s^2
(c) uniform acceleration of 5 m/s^2
(d) non-uniform acceleration of average –10 m/s^2

14 ✱ The following graphs describe objects moving with uniform acceleration, which object of them has the largest acceleration?



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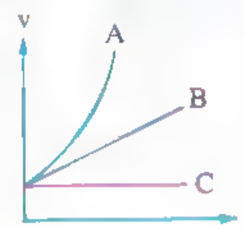
15 The opposite graph represents the relation between the velocity (v) and the time (t) for three bodies A, B and C. then for which of these bodies the acceleration increases with time?

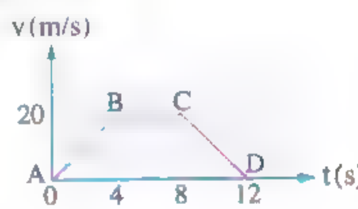


ⓐ Body A ⓑ Body B

ⓒ Body C ⓓ Both A and B

---

16 ✱ The opposite (velocity-time) graph represents the motion of a body in a straight line, then:



(i) The type of the body's acceleration during the interval ....

	AB	BC	CD
ⓐ	positive	positive	positive
ⓑ	positive	positive	negative
ⓒ	positive	zero	negative
ⓓ	negative	zero	positive

(ii) The acceleration by which the body moves from A to B equals ....

ⓐ 0 ⓑ $1.6\ m/s^2$ ⓒ $2.5\ m/s^2$ ⓓ $5\ m/s^2$

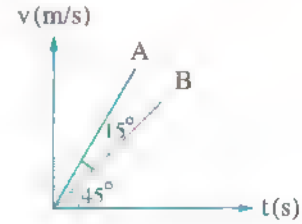
(iii) The acceleration by which the body moves from C to D equals ....

ⓐ $-5\ m/s^2$ ⓑ $-4\ m/s^2$ ⓒ $-2.5\ m/s^2$ ⓓ $-1.6\ m/s^2$

(iv) The distance covered by the body during its motion from B to C equals ....

ⓐ 80 m ⓑ 120 m ⓒ 160 m ⓓ 240 m

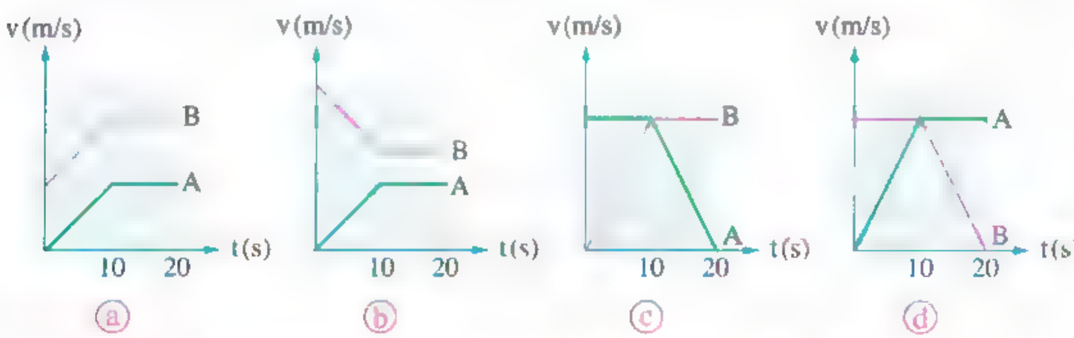
17 * The opposite graph shows the relation between velocity (v) and time (t) of two bodies A and B that start their motion from rest, so the ratio between the accelerations of body A and body B $\left(\frac{a_A}{a_B}\right)$ is ....



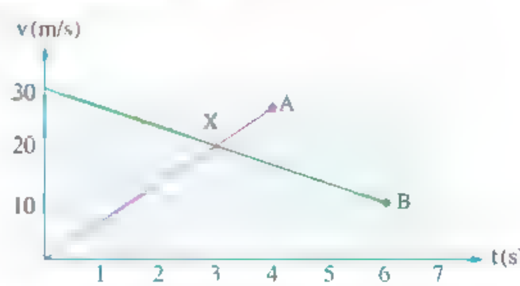
ⓐ $\frac{4}{3}$ ⓑ $\frac{1}{3}$

ⓒ $\frac{\sqrt{3}}{1}$ ⓓ $\frac{\sqrt{2}}{1}$

18 * Car A started its motion from rest with uniform acceleration of 1 m/s^2 in the first 10 s of the journey, while car B was moving with constant velocity of 10 m/s in the same time interval. In the next 10 s car A moved with constant velocity of 10 m/s, while car B was decelerating uniformly by 1 m/s^2. So, the graph that represents the relation between the velocity and the time of the two cars is ....



19 * The opposite graph represents the relation between the velocity of two objects A, B and the time, so which of the following sentences is correct?



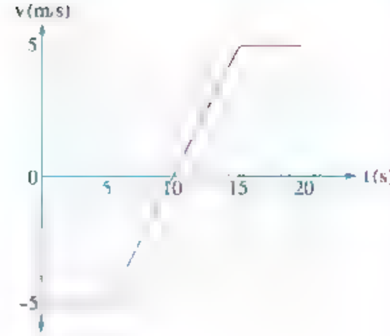
ⓐ A and B move in opposite directions from t = 0 to t = 3 s.

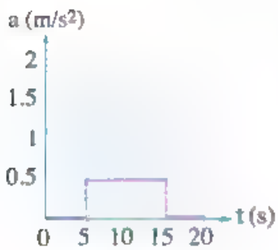
ⓑ The accelerations of A and B have the same direction.

ⓒ The magnitude of the acceleration of A is larger than that of B.

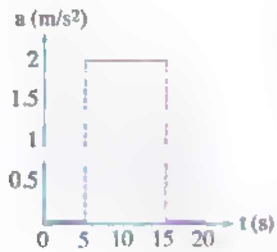
ⓓ The two objects have equal displacements through the first 3 s.

20 ✳ The opposite graph represents the change of the velocity of a body that moves in a straight line with the time, so the graph that represents the relation between the body's acceleration (a) and the time (t) is ..... .

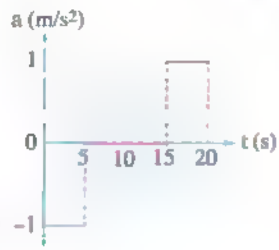




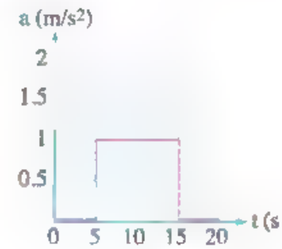
ⓐ



ⓑ



ⓒ

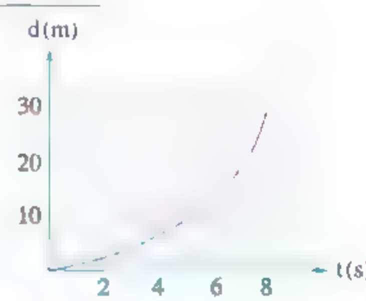


ⓓ

21 ✳ A body started its motion from rest and moved at uniform acceleration. If its average velocity through a time interval of t was 10 m/s, then its average velocity through a time interval of 2 t from the beginning of its motion would be .

ⓐ 10 m/s
ⓑ 20 m/s
ⓒ 30 m/s
ⓓ 40 m/s

22 ✳ The opposite graph represents the relation between the displacement (d) and the time (t) of a body that starts its motion from rest and moves by uniform acceleration of ....



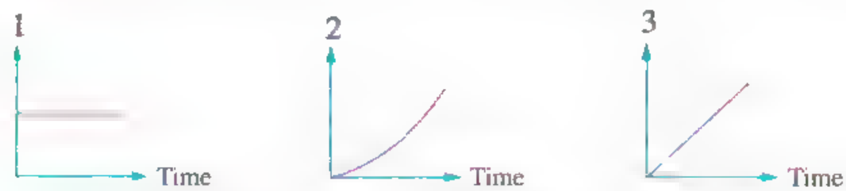
ⓐ $30\ m/s^2$
ⓑ $15\ m/s^2$
ⓒ $\frac{15}{16}\ m/s^2$
ⓓ $\frac{15}{4}\ m/s^2$

Essay questions

1 If the acceleration of an object equals zero, **does this mean that** its velocity must equal zero? **Explain your answer.**

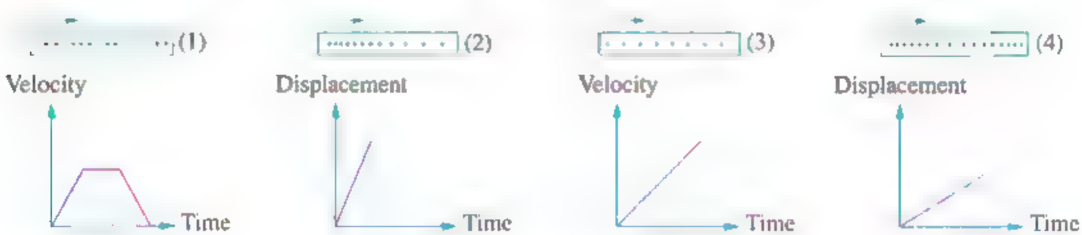
2 **Is** it possible for the velocity of a car to be in the north direction when the car is moving at the same time by an acceleration in the south direction? **Discuss your answer.**

3 A bus is moving with uniform acceleration, where the following graphs represent the relation between the time on the horizontal axis and each of (1), (2) and (3) on the vertical axis:



What are the physical quantities that are represented by the numbers (1), (2) and (3)?

4 You have four ticker-tapes that describe the motion of objects. **Match** each ticker-tape with the proper graph that represents the same motion.



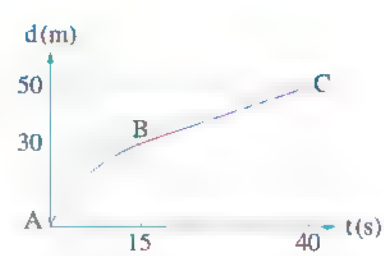
(a) (b) (c) (d)

Questions that measure high levels of thinking

Answered in detail

Choose the correct answer:

1 The opposite graph represents the relation between the displacement (d) and the time (t) for a body that moves in a straight line, then the accelerations by which the body moves during the intervals AB and BC are ....



	AB	BC
ⓐ	negative	positive
ⓑ	negative	zero
ⓒ	positive	positive
ⓓ	positive	zero

2. The opposite (velocity-time) graph represents the motion of a car in a straight road, so which of the following sentences is correct?

ⓐ The car is static at $t = 0$.

ⓑ The car returns to its starting point during 5 s.

ⓒ The displacement of the car increases from $t = 0$ to $t = 5$ s.

ⓓ The acceleration of the car is maximum at $t = 2$ s.

3. The opposite graph represents the relation between the acceleration (a) and the time (t) for a body that moves in a straight line, so the correct arrangement of the intervals (1), (2), (3) according to the magnitude of the change in the velocity of the body during each of them is ....

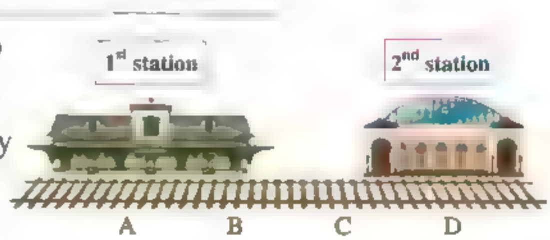
ⓐ $2 < 1 < 3$

ⓑ $1 < 2 < 3$

ⓒ $3 < 1 < 2$

ⓓ $3 < 2 < 1$

4. A train is moving in a straight line between two stations, where it starts its motion from rest at the first station and then it accelerates uniformly from point A to point B. After that the train moves with uniform velocity from point B to point C, then it decelerates uniformly from point C to point D (with the same rate as between A and B) until it stops at the second station. If the distances AB, BC and CD are equal and the trip between the two stations takes 5 minutes, then the time taken by the train to cover each of the three distances is ....



	AB	BC	CD
ⓐ	100 s	120 s	80 s
ⓑ	100 s	100 s	100 s
ⓒ	60 s	180 s	60 s
ⓓ	120 s	60 s	120 s

Test on Chapter 1

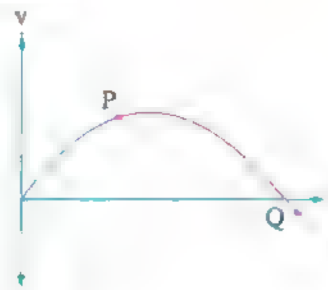
Motion in a Straight Line

Choose the correct answer

1 If a body starts its motion from rest and moves with uniform acceleration a in a straight line, then the average velocity v of the body after time t equals ....

(a) at (b) 2 at (c) $\frac{at}{2}$ (d) $\frac{a}{t}$

2 The opposite (velocity-time) graph represents the motion of a car that is moving in a straight line, so the car at point Q is ....

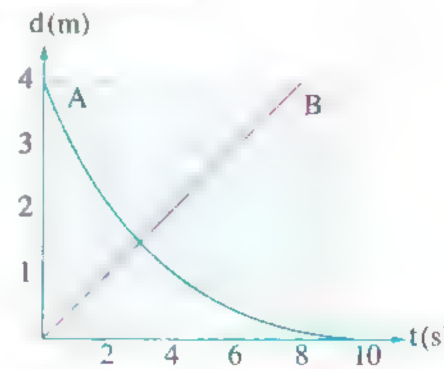


(a) moving with zero acceleration
(b) static
(c) moving in the same direction as at point P
(d) moving in a direction opposite to the direction of motion at point P

3 A car moves with initial velocity of 25 m/s to the north. If its acceleration is 3 m/s^2 to the south, then its velocity after 6 s will be ....

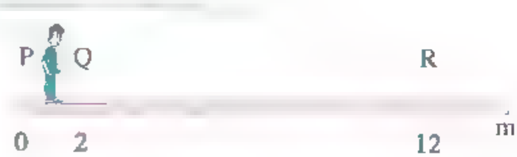
(a) 7 m/s to the north (b) 7 m/s to the south
(c) 20 m/s to the north (d) 20 m/s to the south

4 The opposite graph represents the relation between the displacement (d) and the time (t) of two boys A and B, which of the following statements is correct?



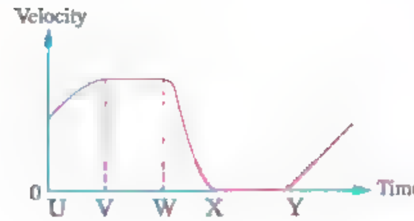
(a) The average velocity of A is larger than the average velocity of B.
(b) B moves with non-uniform velocity.
(c) A moves with uniform velocity.
(d) A and B meet at (t = 3 s).

5 A child is moving in a straight line as shown in the opposite figure. If the child takes 20 s to move from point Q to point R, then his average velocity equals ....



(a) 0.6 m/s (b) 0.5 m/s (c) 1.67 m/s (d) 2 m/s

6. The opposite (velocity-time) graph describes the motion of a car, so the time interval in which the car is at rest is ....



(a) UV (b) VW

(c) WX (d) XY

7. Which case of the following cases is impossible to happen?

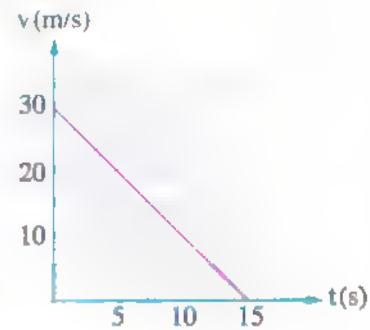
(a) A body is moving with a velocity to the east and its acceleration is in the west direction.

(b) A body is moving with a velocity to the east and its acceleration is in the east direction.

(c) A body is moving with variable velocity and constant acceleration.

(d) A body is moving with constant velocity and variable acceleration.

8. The opposite graph represents the relation between the velocity of a body and the time. From the graph it is clear that the body moves with acceleration of ....



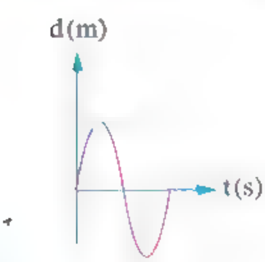
(a) $-10\ m/s^2$

(b) $-2\ m/s^2$

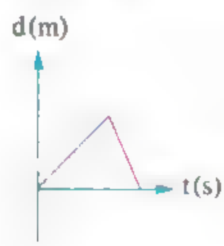
(c) $+5\ m/s^2$

(d) $+2\ m/s^2$

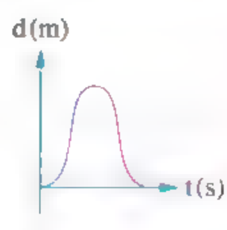
9. A car starts its motion from rest until it reaches velocity v, then it decelerates until it comes to rest. After that it moves in the opposite direction until it returns to its starting point where its velocity changes by the same way as in the first interval. Which of the following graphs represents the relation between the displacement (d) and the time (t) of the car?



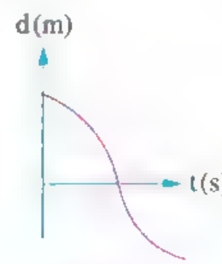
(a)



(b)



(c)



(d)

10. In the opposite figure, the train moves with a uniform velocity of 40 m/s, it takes 6 seconds to pass the standing man, so the length of the train is ....

(a) 100 m (b) 120 m (c) 240 m (d) 480 m

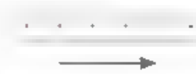
11 A car covered a distance of 20 km in the west direction during 0.5 h, then it changes its direction to cover 20 km in the east direction during 0.5 h. So, the average speed of the car during its journey equals ....

ⓐ 0 ⓑ 40 km/h ⓒ 60 km/h ⓓ 80 km/h

12 If a body starts its motion from rest and moves with uniform acceleration in a straight line, where its average velocity during 2 s from starting its motion is 3 m/s. So, its average velocity during 5 s from starting its motion equals ....

ⓐ 1.2 m/s ⓑ 3 m/s ⓒ 6 m/s ⓓ 7.5 m/s

13 The opposite ticker-tape figure describes the motion of an object in a straight line.
Which of the following graphs represents the relation between the velocity (v) of that object and time (t)?


Direction of motion

ⓐ ⓑ ⓒ ⓓ

14 A body is moving in a straight line with uniform velocity v to cover a distance d, then it moves with velocity 2 v to cover a distance 2 d. So, its average velocity in terms of v equals ....

ⓐ v ⓑ 1.5 v ⓒ 2 v ⓓ 3 v

Answer the following questions

15 After stealing a car from a garage, the thief moved towards the garage's door trying to escape with a uniform velocity of 12 m/s. When he was 60 m away from the door, the security guard pressed a switch to close the door that started to fall down in a speed of 0.2 m/s from a height of 2 m. If the height of the car is 1.4 m, will he succeed to escape? **Explain your answer mathematically**.

16 When does the instantaneous velocity at any instant get equal to the average velocity of a moving body during any interval?

Why a car driver should keep a suitable distance from the front cars?

Chapter 2

Lesson One

Equations of Motion

- You have studied in the previous chapter that acceleration is the change of velocity per unit time and acceleration could be uniform (constant in magnitude and direction) or non-uniform (variable in either magnitude or direction).
- Motion with uniform acceleration has a great importance since it represents the motion of a lot of objects in nature, such as:
  - Falling of objects near the Earth's surface
  - Motion of projectiles.
- The motion of an object whose velocity changes from an initial velocity v_i in a straight line for a displacement d with a uniform acceleration (a) to reach a final velocity v_f after time interval Δt can be expressed by three equations which are called **the equations of motion with uniform acceleration**.

First equation The equation of (velocity-time)

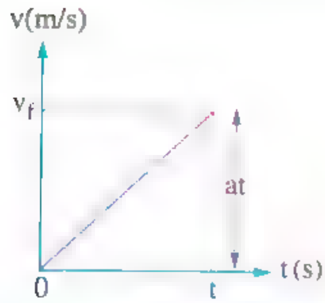
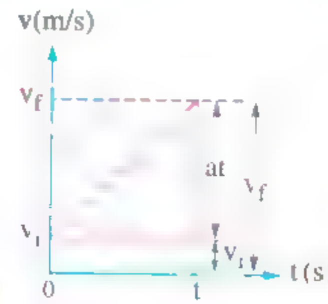
If a body moves with uniform acceleration through an interval of time (Δt) where its velocity at the beginning of this interval is v_i and its velocity at the end of this interval is v_f, then the uniform acceleration (a) by which the body moves is given by the relation: $a = \frac{\Delta v}{\Delta t}$

- If assuming, observing the object motion starts at $t = 0$, then: $\Delta t = t - 0 = t$

$\because \Delta v = v_f - v_i$ $\qquad \therefore a = \frac{v_f - v_i}{t}$

$\therefore at = v_f - v_i$ $\qquad \therefore \boxed{v_f = v_i + at}$

The graph of the first equation of motion for a body's motion with a uniform acceleration that was started to be observed when the body was:

at rest ($v_i = 0$)		moving with a velocity that doesn't equal zero ($v_i \neq 0$)
	will be [illegible] $= \frac{\Delta v}{\Delta t} = a$	

Integration with Mathematics

You can revise how to calculate the slope of a straight line from section (8) page (13).

Note :

- We can find the change in the velocity (Δv) of a body that moves in a straight line with uniform acceleration during a certain time interval by using the graphical relation between the body's acceleration (a) and the time (t) of its motion when we calculate the area under the curve during this interval.
  $\Delta v = a\,\Delta t = a\,(t_f - t_i)$

Example 1

If an aeroplane lands on the runway where its velocity at the moment of touching the ground is 162 km/h and it decelerates uniformly at 0.5 m/s², then the time taken by the aeroplane to stop is ....

ⓐ 30 s ⓑ 45 s ⓒ 60 s ⓓ 90 s

Solution

$v_i = 162 \text{ km/h} = 162 \times \frac{5}{18} = 45 \text{ m/s}$ $v_f = 0$ $a = -0.5 \text{ m/s}^2$

From the first equation of motion:

$v_f = v_i + at$ $0 = 45 + (-0.5)\,t$ $t = \frac{-45}{-0.5} = 90 \text{ s}$

∴ **The correct choice is ⓓ.**

UNIT 2

Example 2

A body moves with a velocity of 20 m/s in the east direction. If it starts to move with an acceleration of 4 m/s² in the west direction, so the magnitude and the direction of its velocity after 10 s will be ....

ⓐ 20 m/s in the east direction
ⓑ 20 m/s in the west direction
ⓒ 35 m/s in the east direction
ⓓ 35 m/s in the west direction

Solution

$v_i = 20$ m/s $a = -4$ m/s² $t = 10$ s $v_f = ?$

Assume that the positive direction of motion is the east direction.

$v_f = v_i + at = 20 + (-4 \times 10) = -20$ **m/s**

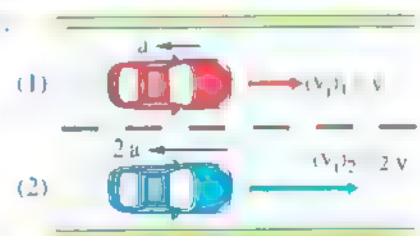
∴ The body moves with velocity of 20 m/s in the west direction.

∴ **The correct choice is ⓑ.**

Notice that: When a body moves with negative acceleration, its velocity decreases till it stops and the acceleration may make the body move in the opposite direction.

Example 3

Two cars move in two straight lines with velocities v and 2 v. The driver of each car applies the brakes, so the velocity of each of them decreases uniformly as in the opposite figure. If car (1) takes time t to stop, then the time taken by car (2) to stop is ....



ⓐ 8 t
ⓑ 4 t
ⓒ 2 t
ⓓ t

Solution

Car (1)	$(v_i)_1 = v$	$a_1 = -a$	$t_1 = t$	$(v_f)_1 = 0$
Car (2)	$(v_i)_2 = 2v$	$a_2 = -2a$	$(v_f)_2 = 0$	$t_2 = ?$

$(v_f)_1 = (v_i)_1 + a_1 t_1$

$0 = v - at$

$v = at$ ①

$(v_f)_2 = (v_i)_2 + a_2 t_2$

$0 = 2v - 2at_2$

$2v = 2at_2$

$v = at_2$ ②

By comparing equation ① by equation ②:

$\therefore t_2 = t$

∴ **The correct choice is ⓓ.**

Example 4

A body was moving in a straight line with velocity 20 m/s. If it starts to move with a uniform acceleration (a) at a certain instant where its average velocity during 10 s after that instant equals 30 m/s, then its acceleration is ....

ⓐ $0.5\ m/s^2$ ⓑ $2\ m/s^2$ ⓒ $4\ m/s^2$ ⓓ $6\ m/s^2$

Solution

$v_i = 20\ m/s$ $\bar{V} = 30\ m/s$ $t = 10\ s$ $a = ?$

$\bar{V} = \frac{v_f + v_i}{2}$ $30 = \frac{v_f + 20}{2}$ $v_f = 40\ m/s$ $v_f = v_i + at$

$a = \frac{v_f - v_i}{t} = \frac{40 - 20}{10} = 2\ m/s^2$ ∴ **The correct choice is ⓑ.**

What if the body has started its motion from rest to move with the same acceleration (a), what will be its average velocity during the first 10 s of its motion?

Test yourself

Answered

1 **Choose the correct answer:** A rocket is launched from the Earth's surface to move vertically in a straight line with a net acceleration of $18\ m/s^2$, so its velocity after 150 s is ....

ⓐ 800 m/s ⓑ 1500 m/s ⓒ 2700 m/s ⓓ 3000 m/s

2 A car was moving in a straight line with initial velocity of 20 m/s towards the north. If it starts to move with an acceleration of $2\ m/s^2$ towards the south, what will be the magnitude and the direction of its velocity after 12 s?

....

....

UNIT 2

Second equation [illegible]

If a body started to move with uniform acceleration (a) through an interval of time (Δt) where its velocity at the beginning of this interval was v_i and its displacement during this interval was d, then the average velocity ($\bar{v}$) of the body during this interval is given by the relation:

$$\bar{v} = \frac{d}{t} \qquad (1)$$

∵ The object moves at uniform acceleration, so the average velocity is also given by the relation:

$$\bar{v} = \frac{v_f + v_i}{2} \qquad (2)$$

From (1) and (2):

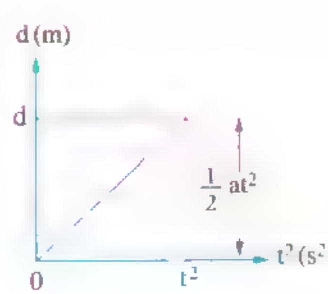
$$\therefore \frac{d}{t} = \frac{v_f + v_i}{2}$$

Substituting for v_f from the first equation of motion ($v_f = v_i + at$):

$$\therefore \frac{d}{t} = \frac{(v_i + at) + v_i}{2} = \frac{2\,v_i + at}{2} = v_i + \frac{1}{2}\,at$$

Multiplying both sides by t: ∴ $d = v_i t + \frac{1}{2}at^2$

The graph of the second equation of motion for a body's motion with a uniform acceleration when its motion started to be observed when the body was at rest $v_i = 0$, can be represented as follows:



$$= \frac{\Delta d}{\Delta t^2} = \frac{1}{2}\,a$$

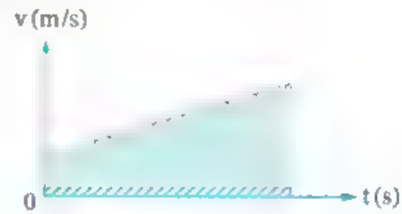
Deriving the second equation of motion graphically

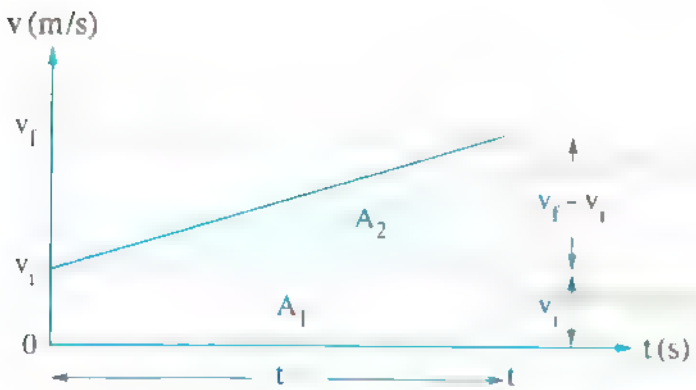
∵ Displacement = Average velocity × Time

∴ From the graph:

Displacement (d) = Area under the (velocity-time) curve

- **The area under the curve is divided into a rectangle and a triangle:**





The area of **the triangle (A_2)**

($\frac{1}{2}$ × Base × Height)

$$A_2 = \frac{1}{2} t (v_f - v_i)$$

From the first equation of motion $v_f - v_i = at$

$$A_2 = \frac{1}{2} at^2$$

- The area of the rectangle (A_1)

(Length × Width)

$$A_1 = v_i t$$

∵ $d = A_1 + A_2$ ⟹ ∴ $d = v_i t + \frac{1}{2} at^2$

Example 1

A body moves in a straight line with a uniform velocity of 4 m/s, then it starts to move with a uniform acceleration of 4 m/s² for 8 s, so the displacement of the body during this interval is ....

ⓐ 32 m ⓑ 48 m ⓒ 128 m ⓓ 160 m

Solution

$v_i = 4$ m/s $a = 4$ m/s² $t = 8$ s

$d = v_i t + \frac{1}{2} a t^2$

$= (4 \times 8) + (\frac{1}{2} \times 4 \times (8)^2) = 160$ m

∴ The correct choice is ⓓ.

What if the body starts its motion from rest with uniform acceleration and it has the same displacement during the same interval of time as the previous case, **what** will be its acceleration in this case?

Example 2

Two cars start their motion from rest, from the same position and in the same direction as in the opposite figure, after 10 s, the distance between them becomes 200 m, so the value of a is ....

ⓐ $2\ m/s^2$ ⓑ $4\ m/s^2$

ⓒ $6\ m/s^2$ ⓓ $8\ m/s^2$

Solution

$(v_i)_1 = 0$ $a_1 = a$ $(v_i)_2 = 0$ $a_2 = 2a$ $t = 10\ s$ $x = 200\ m$ $a = ?$

Clue

The first car covers displacement d_1 after time $t = 10\ s$ and the second car covers displacement d_2 after the same time and the difference between the displacements of the two cars at this time is 200 m.

$\because d = v_i t + \frac{1}{2} a t^2$, $v_i = 0$

$\therefore d_1 = \frac{1}{2} a t^2$, $d_2 = \frac{1}{2} \times 2 a t^2 = a t^2$

$\because d_2 - d_1 = x$

$\therefore d_2 - d_1 = 200$, $a t^2 - \frac{1}{2} a t^2 = 200$

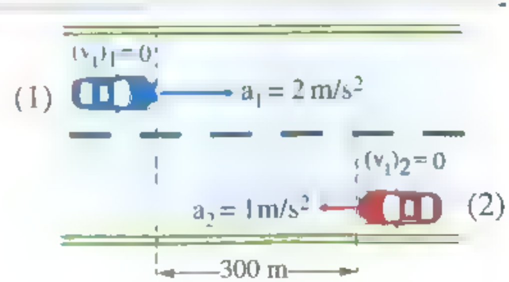
$\therefore \frac{1}{2} a t^2 = 200$, $\because t = 10\ s$

$\therefore \frac{1}{2} a (10)^2 = 200$, $a = 4\ m/s^2$

$\therefore$ **The correct choice is ⓑ.**

Example 3

Two cars are moving from rest in two straight opposite directions, so they will meet when car (1) has moved a distance of ....



ⓐ 100 m ⓑ 150 m

ⓒ 200 m ⓓ 300 m

Solution

$(v_i)_1 = 0$ | $a_1 = 2\ m/s^2$ | $(v_i)_2 = 0$ | $a_2 = 1\ m/s^2$ | $d = 300\ m$ | $d_1 = ?$

Clue

The time intervals taken by each car until they meet are equal.

$$d_1 = (v_i)_1 t + \frac{1}{2} a_1 t^2$$
$$d_1 = 0 + \frac{1}{2} \times 2 \times t^2$$
$$d_1 = t^2 \quad (1)$$

$$d_2 = (v_i)_2 t + \frac{1}{2} a_2 t^2$$
$$d - d_1 = (v_i)_2 t + \frac{1}{2} a_2 t^2$$
$$300 - d_1 = 0 + \frac{1}{2} \times 1 \times t^2$$
$$600 - 2\,d_1 = t^2 \quad (2)$$

By substituting from equation (1) in equation (2):

$\therefore d_1 = 600 - 2\,d_1$

$\therefore 3\,d_1 = 600$

$\therefore$ **$d_1 = 200$ m**

$\therefore$ **The correct choice is (c).**

What if car (2) is moving in the same direction of car (1), what will be the distance covered by car (2) when car (1) catches it?

Example 4

The opposite figure shows a train that started its motion from rest with a uniform acceleration of 1 m/s² and at the same moment a person moved inside the train from position x in the same direction of the train's motion at a uniform velocity of 1 m/s, so the displacement of this person from position x after 5 s is ....

(a) 5 m (b) 7.5 m (c) 12.5 m (d) 17.5 m

Solution

$(v_i)_1 = 0$ | $a_1 = 1\ m/s^2$ | $v_2 = 1\ m/s$ | $t = 5\ s$ | $d = ?$

Clue

The displacement of the person from position x after 5 s is the sum of the displacement due to the train's motion with uniform acceleration and the displacement due the person's motion with uniform velocity.

$$d = d_1 + d_2 = (v_i)_1\, t + \frac{1}{2}\, a_1\, t^2 + v_2\, t$$

$$= 0 + (\frac{1}{2} \times 1 \times (5)^2) + (1 \times 5) = 17.5 \text{ m}$$

∴ The correct choice is ⓓ.

What if the person moves in the opposite direction of the train's motion, **what** will be his displacement from point x after 5 s?

Example 5

A driver of a car that moves in a straight line notices a truck in front of him that moves in the same direction with uniform velocity of 25 km/h, so the driver of the car applies the brakes when the car's velocity was 80 km/h and the truck was at 12 m from the car. If the car decelerates at 8 m/s², then the car collides with the truck after ....

ⓐ 0.7 s ⓑ 1.1 s ⓒ 2.2 s ⓓ 3.4 s

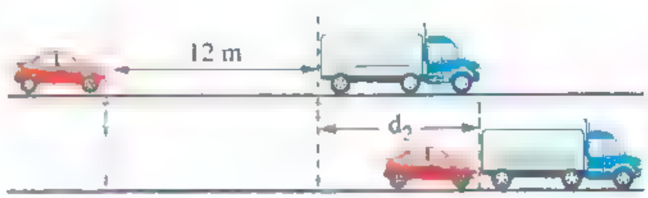
Solution

$(v_i)_1 = 80 \text{ km/h} = 80 \times \frac{5}{18} = 22.22 \text{ m/s}$ $v_2 = 25 \text{ km/h} = 25 \times \frac{5}{18} = 6.94 \text{ m/s}$

$d = 12 \text{ m}$ $a_1 = -8 \text{ m/s}^2$ $t = ?$

Clue

When the car collides with the truck, the car will have moved 12 m in addition to the distance moved by the truck (d_2).



- From the second equation of motion:

$$d_1 = (v_i)_1\, t + \frac{1}{2}\, a_1\, t^2 \quad , \quad d_2 = v_2\, t$$

$$d + d_2 = (v_i)_1\, t + \frac{1}{2}\, a_1\, t^2$$

$$d + v_2\, t = (v_i)_1\, t + \frac{1}{2}\, a_1\, t^2$$

$$12 + (6.94\, t) = (22.22\, t) + (\frac{1}{2} \times (-8)\, t^2)$$

$$-4\, t^2 + 15.28\, t - 12 = 0$$

Integration with Mathematics

You can revise how to solve second degree equation with one unknown from section (9) page (15).

Solving the equation by using the calculator:

$\therefore t_1 = 1.1$ s $\qquad t_2 = 2.7$ s

- Assuming that the car won't collide with the truck and it will overtake the truck as it is moving with negative acceleration till the truck reaches it, so the time taken for that to happen is the longer value (t_2) while the shorter value (t_1) is the time taken by the car to reach the truck in the first time.

$\therefore t = t_1 = 1.1$ s

$\therefore$ The correct choice is (b).

What if the car's driver applies the brakes when the velocity of the truck was 25 km/h where the car decelerates at 4 m/s^2, **what** will be the time taken by the car to collide with the truck?

Test yourself

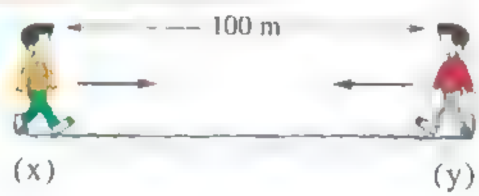
Answered

Choose the correct answer:

1 A car starts its motion from rest in a straight line with uniform acceleration for 10 s to cover a distance of 100 m, then the distance covered by it after 20 s from the start of its motion equals ....

(a) 200 m (b) 300 m (c) 400 m (d) 800 m

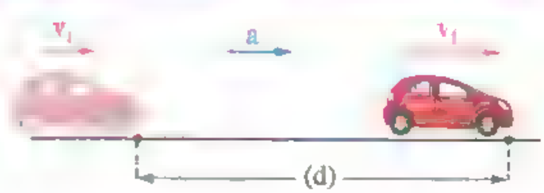
2 The opposite figure shows two people x, y where the distance between them is 100 m. If they move towards each other where person x moves with uniform velocity of 2 m/s and person y starts his motion from rest with uniform acceleration of 0.5 m/s^2, then the two people meet after ....



(a) 400 s (b) 40 s (c) 26.13 s (d) 16.4 s

Third equation — The equation of (displacement – velocity)

If a body moves with uniform acceleration in a straight line during interval of time (t) where its velocity at the beginning of this interval was v_i and its velocity at the end of this interval is v_f, then the displacement (d) covered by the body is given by the relation:



$d = \bar{v}\, t$ (1)

$\bar{v} = \dfrac{v_f + v_i}{2}$ (2)

From the first equation of motion: $t = \dfrac{v_f - v_i}{a}$ (3)

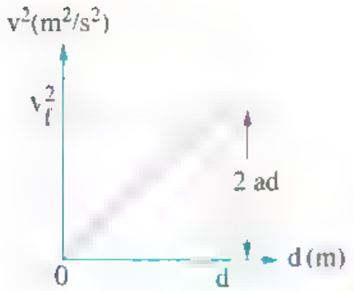
Substituting from , in equation :

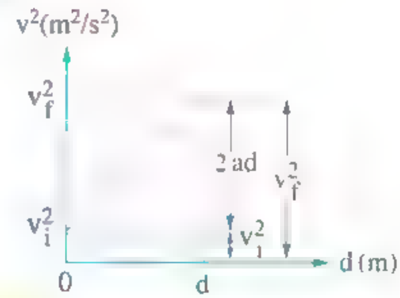
$\therefore d = \frac{v_f + v_i}{2} \times \frac{v_f - v_i}{a}$ $\qquad \therefore d = \frac{v_f^2 - v_i^2}{2a}$ $\qquad \therefore \boxed{2ad = v_f^2 - v_i^2}$

[illegible] observed when the body was:

at rest ($v_i = 0$)	moving with a velocity that doesn't equal zero ($v_i \neq 0$)

will be





Slope $= \frac{\Delta v^2}{\Delta d} = 2a$

Example 1

A car moves with a velocity of 36 km/h on a straight road. When the car collides with a concrete barrier, it stops after 0.5 m of its front part has been smashed, then the average of the acceleration of the car during the collision is ....

ⓐ $-25\ m/s^2$ ⓑ $-40\ m/s^2$

ⓒ $-50\ m/s^2$ ⓓ $-100\ m/s^2$

Solution

$v_i = 36\ km/h = 36 \times \frac{5}{18} = 10\ m/s$ $\quad d = 0.5\ m$ $\quad v_f = 0$

From the third equation of motion: $v_f^2 = v_i^2 + 2ad$

$0 = (10)^2 + (2a \times 0.5)$

$a = -100\ m/s^2$ $\qquad \therefore$ The correct choice is ⓓ.

What if we want to calculate the interval of time taken by the car from the beginning of collision till it stops, **what** will be your answer?

Example 2

A man drove a car at a uniform velocity of 30 m/s. Suddenly, he saw a child crossing the street and he applied the brakes after 0.5 s from seeing the child to decelerate the car uniformly at 9 m/s² till it stopped. So, the displacement of the car from the moment of seeing the child till it stopped is ....

ⓐ 65 m ⓑ 50 m ⓒ 15 m ⓓ 10 m

Solution

$v = v_i = 30$ m/s $t_{reaction} = 0.5$ s $a = -9$ m/s^2 $v_f = 0$

Clue

When the driver saw the child, he applied the brakes after 0.5 s and during this time interval the car covered displacement d_1 and when the driver applied the brakes, the car decelerated uniformly till it stopped after covering displacement d_2. So, the total displacement covered by the car (d) is: $d = d_1 + d_2$

- Displacement of the car during the reaction time till using the brakes (uniform velocity):

$d_1 = v\, t_{reaction} = 30 \times 0.5 = 15$ m

- Displacement of the car when applying the brakes (uniform deceleration):

From the third equation of motion:

$2\, a\, d_2 = v_f^2 - v_i^2$

$\therefore 2\, a\, d_2 = -v_i^2$

$d_2 = \frac{-v_i^2}{2\,a} = \frac{-(30)^2}{2 \times (-9)} = 50$ m

$\therefore d = 15 + 50 = 65$ m

$\therefore$ **The correct choice is ⓐ.**

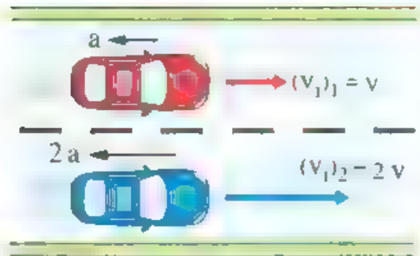
What if the child was at a distance of 62 m from the car when the driver saw him and the child was running in the same direction of the car's motion at velocity 1 m/s, **would** the car hit the child?

3 Test yourself

Answered

Choose the correct answer:

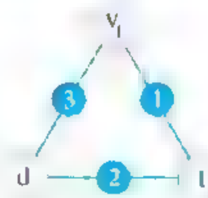
The two cars in the opposite figure move in straight lines at velocities v and 2 v. Each driver of the two cars applies the brakes, so the cars decelerate uniformly as shown in the figure. If the displacement of the first car till it stops is d, then the displacement of the second car till it stops is ....



ⓐ 8 d ⓑ 4 d ⓒ 2 d ⓓ $\frac{d}{2}$

Notes :

(1) The opposite triangle would help in solving problems based on the equations of motion where the number written between two (given and unknown) quantities indicates the order of the equation that can be used to solve the problem.



(2) The following table shows some special cases for the equations of motion:

	The general formula	A body starts from rest ($v_i = 0$)	A body stops ($v_f = 0$)	A body moves with uniform velocity ($a = 0$)
1	$v_f = v_i + at$	$v_f = at$	$v_i = -at$	$v_f = v_i$
2	$d = v_i t + \frac{1}{2} at^2$	$d = \frac{1}{2} at^2$	$d = -\frac{1}{2} at^2$	$d = v_i t$
3	$2ad = v_f^2 - v_i^2$	$2ad = v_f^2$	$2ad = -v_i^2$	$v_f = v_i$

(3) Type of problems like: "an object moves according to a given relation" You should modify the given equation to be similar to one of the three equations of motion and then match them to find the required answer.

Example 1

An object moves with uniform acceleration in a straight line according to the relation; $d = 14\ t + 10\ t^2$, where (d) is measured in meters and (t) is measured in seconds. So, the initial velocity and the acceleration of the body are ....

ⓐ 10 m/s, 10 m/s^2

ⓑ 10 m/s, 15 m/s^2

ⓒ 14 m/s, 20 m/s^2

ⓓ 14 m/s, 25 m/s^2

Solution

Clue

Match the given equation by the similar equation from the three equations of motion

The second equation of motion: $d = \boxed{v_i}\, t + \boxed{\frac{1}{2}a}\, t^2$ ①

$d = \boxed{14}\, t + \boxed{10}\, t^2$ ②

From equations ① and ②:

$\because v_i t = 14\, t$ $\therefore v_i = 14$ m/s

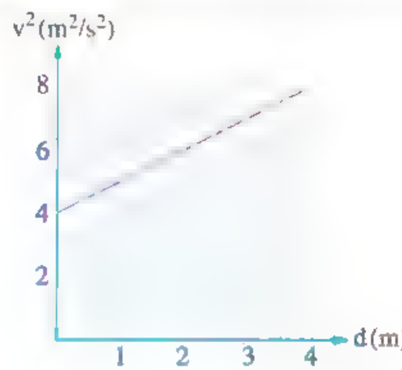
$\because \frac{1}{2} a t^2 = 10\, t^2$ $\therefore a = 20$ m/s^2

$\therefore$ **The correct choice is ⓒ.**

What if we want to calculate the distance covered by the object after 5 s, **what** will be your answer?

Example 2

The opposite graph represents the relation between the square of velocity (v^2) and the displacement (d) of a body that moves by uniform acceleration in a straight line, hence the time taken by the body to change its velocity from 2 m/s to 16 m/s equals ....



ⓐ 35 s ⓑ 28 s

ⓒ 19 s ⓓ 12 s

Solution

$\because v_f^2 - v_i^2 = 2\, a\, \Delta d$, $\therefore \text{Slope} = \frac{\Delta v^2}{\Delta d} = \frac{8-4}{4-0} = 1$ m/s^2

$\therefore \text{Slope} = 2\, a = 1$ $\therefore a = 0.5$ m/s^2

From the first equation of motion: $v_f = v_i + at$

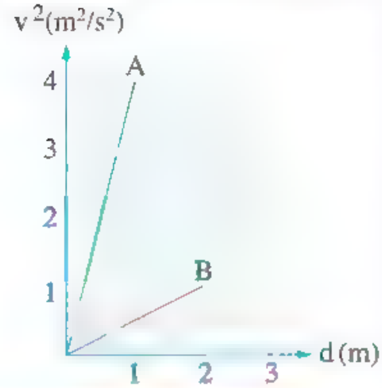
$16 = 2 + 0.5\, t$, $\therefore t = 28$ s

$\therefore$ **The correct choice is ⓑ.**

What if the body starts its motion from rest and moves with the same acceleration, **what** will be the time taken by the body to reach a velocity of 16 m/s?

Example 3

The opposite graph of velocity squared (v^2) versus displacement (d) represents the motions of two bodies A, B from rest, so the ratio between their final velocities after passing the same interval of time $\left(\frac{v_A}{v_B}\right)$ is ....



ⓐ $\frac{8}{1}$ ⓑ $\frac{4}{1}$

ⓒ $\frac{1}{8}$ ⓓ $\frac{1}{4}$

Solution

$\because v_f^2 - v_i^2 = 2\,ad \quad , \quad v_i = 0$

$\therefore v_f^2 = 2\,ad \quad \therefore a = \frac{\text{Slope}}{2}$

$$\therefore \frac{a_A}{a_B} = \frac{(\text{Slope})_A}{(\text{Slope})_B} = \frac{\frac{4-0}{1-0}}{\frac{1-0}{2-0}} = \frac{8}{1}$$

$\because v_f = v_i + at \quad , \quad v_i = 0 \therefore v_f = a\,t$

After passing the same interval of time:

$$\therefore \frac{v_A}{v_B} = \frac{a_A}{a_B} = \frac{8}{1}$$

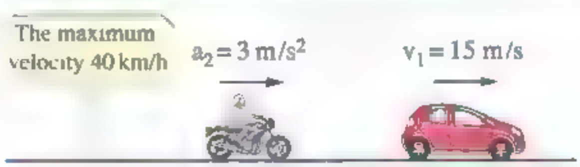
$\therefore$ The correct choice is ⓐ.

Integration with Mathematics

You can revise the direct proportionality from section (7) page (12).

Example 4

A car that is moving with a uniform velocity of 15 m/s passes in front of a traffic sign that indicates the maximum allowed speed on this road as 40 km/h. Just at the instant when the car passes in front of the sign, a policeman that stands by his motorcycle beside the sign starts from rest to chase the car with acceleration of 3 m/s², then:



(i) The time taken by the policeman to catch the car is ....

ⓐ 5 s ⓑ 10 s ⓒ 15 s ⓓ 20 s

(ii) The velocity of the motorcycle at the moment of reaching the car is ....

ⓐ 10 m/s ⓑ 20 m/s ⓒ 30 m/s ⓓ 40 m/s

(iii) The displacement of the car and the motorcycle from the traffic sign when the motorcycle catches the car is ....

ⓐ 50 m ⓑ 100 m ⓒ 150 m ⓓ 200 m

Solution

$v_1 = 15$ m/s | $(v_i)_2 = 0$ | $a_2 = 3$ m/s^2

- The car moves with uniform velocity:

$\because v_1 = \frac{d}{t}$ $\qquad\qquad$ $\therefore d = v_1 t$

- The motorcycle moves with uniform acceleration, so from the second equation of motion:

$d = (v_i)_2 t + \frac{1}{2} a_2 t^2 \quad , \quad (v_i)_2 = 0$

$\because$ The car and the motorcycle cover the same displacement from the sign when the motorcycle catches the car.

$\therefore v_1 t = \frac{1}{2} a_2 t^2$

$15 = \frac{1}{2} \times 3 t$

$t = 10$ s

$\therefore$ **The correct choice is ⓑ.**

(ii) From the first equation of motion:

$(v_f)_2 = (v_i)_2 + a_2 t = 0 + (3 \times 10) = 30$ m/s

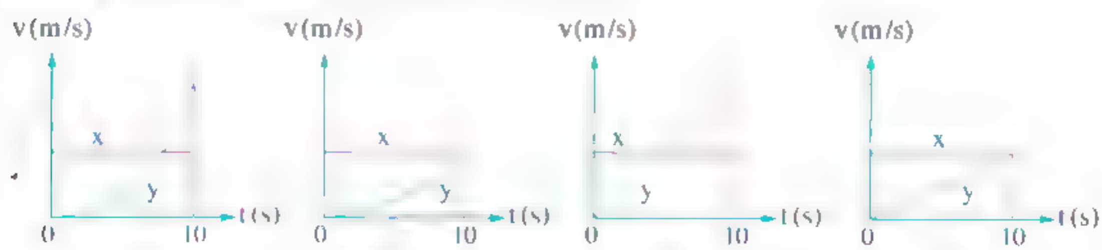
$\therefore$ **The correct choice is ⓒ.**

(iii) From the second equation of motion:

$d = (v_i)_2 t + \frac{1}{2} a_2 t^2 = 0 + (\frac{1}{2} \times 3 \times (10)^2) = 150$ m

$\therefore$ **The correct choice is ⓒ.**

What if we want to plot a graph representing the change of velocity (v) for the car (x) and the motorcycle (y) versus time (t), **which** of the following graphs represents this relation correctly?



ⓐ ⓑ ⓒ ⓓ

Life application (safety skills)

To avoid the dangers of exceeding prescribed speeds and to save souls, traffic instructions should be followed such as:

Leaving an appropriate distance between vehicles to allow the driver to stop safely in case of emergency where more spacing between vehicles is required when:

- The speed of cars gets higher.
- The road is wet or covered with oil.
- The vehicles are huge such as trucks.

Test yourself

Answered

1 A ship was moving in a straight line, so during increasing its velocity uniformly from 20 m/s to 30 m/s, it covered a distance of 200 m, **then calculate** the time taken by the ship to cover this distance.

....

....

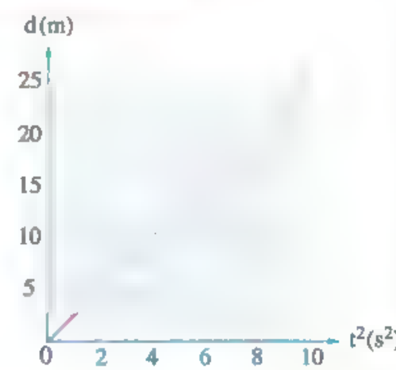
....

2 **Choose the correct answer :**

The opposite graph represents the relation between the displacement (d) and the square of time (t^2) for a body that has moves in a straight line from rest with a uniform acceleration, so the body's velocity after 10 s is ....

(a) 25 m/s (b) 50 m/s

(c) 100 m/s (d) 125 m/s



Chapter 2

Questions on Lesson One

Equations of Motion

To watch videos of how to solve questions use the App

GPS

Interactive test

The questions signed by ✳ are answered in detail.

First Multiple choice questions

First equation of motion

1. ✳ What is the time required for a plane to completely stop when landing on a straight runway of an airport, if you know that its velocity was 50 m/s when touching the surface of the runway and it decelerates uniformly by a rate of 2 m/s^2?

   (a) 5 s (b) 10 s (c) 12.5 s (d) 25 s

2. ✳ A radar monitors the motion of a car that moves on a straight road with uniform acceleration of $-4\ m/s^2$, it finds that the velocity of the car was 18 m/s at 10:05:00 am, then its velocity at 10:04:57 am equals ....

   (a) 30 m/s (b) 22 m/s (c) 14 m/s (d) 10 m/s

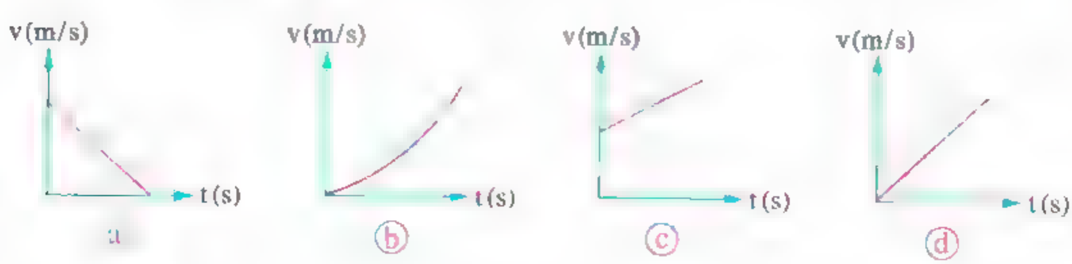
3. ✳ A train moves in a straight line, then the time required to change its velocity from 72 km/h to 13 km/h with a constant acceleration of 2 m/s^2 equals ....

   (a) 6.2 s (b) 8.2 s (c) 11.8 s (d) 29.5 s

4. ✳ If an object starts motion from rest in a straight line with uniform acceleration and takes time t in seconds which is numerically equal to the magnitude of its acceleration (a) in m/s^2 to reach a final velocity of 16 m/s, so the magnitude of its acceleration is ....

   (a) 2 m/s^2 (b) 4 m/s^2 (c) 8 m/s^2 (d) 16 m/s^2

5. The (velocity-time) graph that represents the motion of an object that is observed from an initial velocity (v_i) which is not equal to zero where it moves at uniform positive acceleration (a) during time (t) is ....

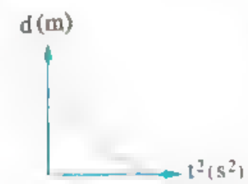


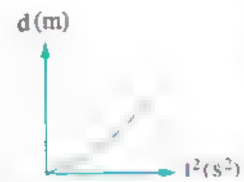
Second equation of motion

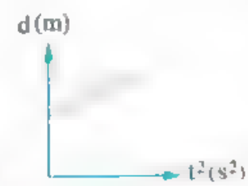
6 If the displacement of a body that moves with uniform acceleration is given by the relation; $d = v_i t + \frac{1}{2} at^2$ and the body starts its motion with acceleration $a = 2\ m/s^2$ when its initial velocity $v_i = 10\ m/s$, then its displacement after 10 s is ......

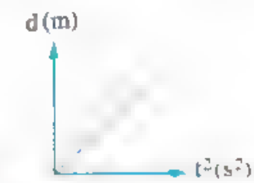
(a) 100 m　　(b) 200 m　　(c) 300 m　　(d) 400 m

7 The graph of displacement (d) versus time squared (t^2) that represents the motion of an object starting from rest and moving in a straight line with uniform positive acceleration is ......









(d)

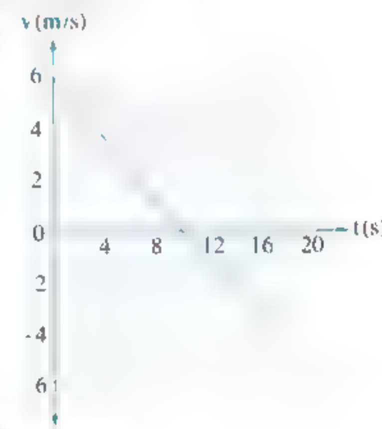
8 ✻ The opposite graph represents the variation of the velocity of a body versus time during 20 s, so the total displacement covered by the body equals ....

(a) 108 m

(b) 36 m

(c) 18 m

(d) 0



9 ✻ A body moves in a straight line with uniform velocity of 4 m/s for 8 s, then it moves in the same direction with a uniform acceleration of $4\ m/s^2$ for 6 s, so the total distance covered by the body equals ....

(a) 128 m　　(b) 80 m　　(c) 68 m　　(d) 56 m

10 ✻ A body starts its motion from rest and moves in a straight line with uniform acceleration to cover a distance d during a time interval t, so it covers during a time interval 2 t from the start of its motion a distance ....

(a) d　　(b) 2 d　　(c) 4 d　　(d) $\sqrt{2}$ d

11 ✻ Two bodies start their motions from rest in straight lines with uniform accelerations to cover a distance d. If the time taken by the first body to cover this distance is double the time taken by the second body, then the ratio between the acceleration of the first body and the acceleration of the second body $(\frac{a_1}{a_2})$ is ....

$\frac{1}{1}$　　$\frac{1}{2}$　　$\frac{1}{4}$　　$\frac{1}{16}$

12 ✳ Two cars start their motions from rest and from the same position in two opposite directions with uniform acceleration of magnitudes as in the opposite figure. After 10 s, the distance between the two cars becomes 300 m, then the magnitude of acceleration (a) equals ....

ⓐ $1.5\ m/s^2$ ⓑ $300\ m/s^2$ ⓒ $2\ m/s^2$ ⓓ $30\ m/s^2$

13 ✳ A train of length 100 m enters a straight tunnel of length 1 km with a velocity of 4 m/s. If the train is moving with an acceleration of $0.5\ m/s^2$, then the required time for the entire train to leave the tunnel is ....

ⓐ 550 s ⓑ 58.81 s ⓒ 20.31 s ⓓ 20 s

Third equation of motion

14 A motorcyclist has started motion from rest in a straight line at a uniform acceleration of $0.5\ m/s^2$, so its velocity will reach 7 m/s through a displacement of ....

ⓐ 24.5 m ⓑ 49 m ⓒ 98 m ⓓ 196 m

15 ✳ A bullet collided with a static target with a velocity of 100 m/s. The bullet penetrated the target 1 m deep till it stopped, so the average acceleration by which the bullet moved inside the target equals ....

$5 \times 10^2\ m/s^2$ $5 \times 10^3\ m/s^2$ $-5 \times 10^2\ m/s^2$ $-5 \times 10^3\ m/s^2$

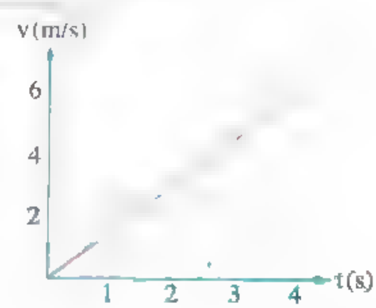
16 ✳ A car was moving with a velocity of 56 km/h so that the minimum distance that would be taken by the car to stop is 12 m. If the car moves with a velocity of 113 km/h assuming that the acceleration is constant in both cases, then the minimum distance that would be taken by the car to stop is ....

ⓐ 97.7 m ⓑ 49.2 m ⓒ 48.9 m ⓓ 24.4 m

17 ✳ Car accelerates uniformly from rest to reach velocity v after covering a distance d, so the velocity of the car after covering a distance 2d from starting its motion is ....

ⓐ v ⓑ $\sqrt{2}\ v$ ⓒ 2 v ⓓ 4 v

18 ✳ The opposite graph of velocity (v) versus time (t) represents the motion of a car with a uniform acceleration, so the velocity of the car after 100 m from starting its motion will be ....



ⓐ 10 m/s ⓑ $10\sqrt{3}\ m/s$
ⓒ $10\sqrt{2}\ m/s$ ⓓ 20 m/s

More than one equation of motion

19 * A body starts its motion from rest with a uniform acceleration, so if its average velocity equals 10 m/s when it covers a displacement of 20 m, then its average velocity during 8 s from starting its motion equals ....

(a) 2 m/s (b) 40 m/s (c) 10 m/s (d) 80 m/s

20 * An electron in the cathode ray tube is accelerated uniformly in a straight line from 2×10^4 m/s to 6×10^6 m/s through a distance of 1.5 cm, then the time taken by the electron to cover this distance equals ....

(a) 4.98×10^{-7} s (b) 5.01×10^{-7} s (c) 5.01×10^{-9} s (d) 4.98×10^{-9} s

21 * A car was moving at 20 m/s in a straight line. When the brakes were applied, it decelerated uniformly at 2 m/s^2, then:

(i) The time required for the car to stop equals ....

(a) 40 s (b) 20 s (c) 10 s (d) 5 s

(ii) The distance covered till it stops equals ....

(a) 50 m (b) 100 m (c) 300 m (d) 400 m

(iii) The average velocity equals ....

(a) 2.5 m/s (b) 5 m/s (c) 10 m/s (d) 15 m/s

22 * A body was moving with an initial velocity of 40 m/s when it has acquired an acceleration of – 4 m/s^2, then:

(i) The distance covered during 5 s after the body has acquired the acceleration equals ....

(a) 100 m (b) 150 m (c) 250 m (d) 300 m

(ii) The time taken by the body from that moment till it stops equals ....

(a) 1 s (b) 2.5 s (c) 5 s (d) 10 s

23 * A driver saw the red traffic light at 100 m away from him when he was moving with 80 km/h, so he used the brakes to decelerate at 2 m/s^2, so which of the following sentences is correct?

(a) The driver wouldn't pass the traffic light.

(b) The driver would pass the traffic light with 147 m.

(c) The driver would pass the traffic light with 23 m.

(d) The car would stop after 9 s from the moment of applying the brakes.

24 ✳ A man was driving a car in a straight road where he suddenly saw a falling tree that closes the road, so he applied the brakes to slow down the car by uniform acceleration of 5.6 m/s^2 nevertheless he hit the tree after 4.2 s. If the tree was 62.4 m away from the car when the brakes were applied, so the velocity by which the car collides with the tree equals ....

ⓐ 3.1 m/s ⓑ 5.8 m/s ⓒ 8.8 m/s ⓓ 17.6 m/s

25 ✳ A vehicle started motion from rest with a uniform acceleration of 2 m/s^2 for 6 s and then it moved at uniform velocity for half a minute. Next to that, the brakes were applied to decelerate the vehicle to stop within 5 s, then:

(i) The greatest velocity reached by the vehicle equals ....

ⓐ 30 m/s ⓑ 15 m/s ⓒ 12 m/s ⓓ 6 m/s

(ii) The total distance covered by the car equals ....

ⓐ 213 m ⓑ 390 m ⓒ 396 m ⓓ 426 m

26 ✳ A car has started its motion from rest with uniform acceleration of 2 m/s^2. After moving a distance of 100 m, the driver turned the engine off, so the car stopped 5 s afterwards, then:

(i) The acceleration of the car during the last 5 seconds equals ....

ⓐ 8 m/s^2 ⓑ 4 m/s^2 ⓒ -4 m/s^2 ⓓ -8 m/s^2

(ii) The distance covered during the last 5 seconds equals ....

ⓐ $25\sqrt{2}$ m ⓑ 50 m ⓒ 90 m ⓓ 150 m

27 ✳ Two cars A and B start their motions from rest in straight lines from the same point at the same instant. If car A moves with acceleration a and car B moves with acceleration 1.5 a so that after 50 s the velocity of car B becomes larger than the velocity of car A by 50 m/s, then:

(i) The acceleration a equals ....

ⓐ 0.2 m/s^2 ⓑ 0.4 m/s^2 ⓒ 1 m/s^2 ⓓ 2 m/s^2

(ii) The difference between the covered distance by the two cars A and B equals ....

ⓐ 625 m ⓑ 1250 m ⓒ 3750 m ⓓ 4375 m

28 ✳ The displacement (d) of a body that moves in a straight line at any instant (t) is calculated from the relation; $d = 5\,t - 3\,t^2$, then:

(Given that: (d) is measured in meters, (t) is measured in seconds)

(i) The initial velocity of the body equals ....

ⓐ 11 m/s ⓑ 8 m/s ⓒ 6.5 m/s ⓓ 5 m/s

(ii) The acceleration by which the body moves equals ....

ⓐ $-6\ m/s^2$ ⓑ $3\ m/s^2$ ⓒ $-3\ m/s^2$ ⓓ $6\ m/s^2$

(iii) The time taken for the body to stop equals ....

ⓐ 0.63 s ⓑ 0.73 s ⓒ 0.83 s ⓓ 0.93 s

(iv) The velocity of the body after covering a distance of 2 m equals ....

ⓐ 21 m/s ⓑ 13 m/s ⓒ 7.5 m/s ⓓ 1 m/s

29 ✱ An object is moving in a straight line according to the relation; $t = \frac{1}{2} v_f - 6$ where (t) is the time of motion measured in seconds and (v_f) is the velocity of the body measured in meter/second, then:

(i) The initial velocity of the body equals ....

ⓐ 24 m/s ⓑ 12 m/s ⓒ 6 m/s ⓓ 3 m/s

(ii) The acceleration by which the body moves equals ....

ⓐ $4\ m/s^2$ ⓑ $-4\ m/s^2$ ⓒ $2\ m/s^2$ ⓓ $-2\ m/s^2$

(iii) The distance covered during 10 s equals ....

ⓐ 320 m ⓑ 220 m ⓒ 160 m ⓓ 130 m

30 ✱ A body is moving according to the relation; $t = \sqrt{\frac{2d}{3}}$, so the velocity of the body after 4 s is ....

(Knowing that: (d) is the displacement of the body measured in meters, (t) is the time of motion measured in seconds)

ⓐ $\frac{2}{3}$ m/s ⓑ 3 m/s ⓒ 4 m/s ⓓ 12 m/s

31 ✱ A body moves in a straight line with a uniform acceleration according to the relation; $v_f = \sqrt{36 + 5d}$ where (d) is the displacement of the body measured in meters and (v_f) is the velocity of the body measured in meter/second, then:

(i) The initial velocity of the body equals ....

ⓐ 8 m/s ⓑ 6 m/s ⓒ 5 m/s ⓓ 3 m/s

(ii) The acceleration by which the body moves equals ....

ⓐ $2.5\ m/s^2$ ⓑ $3\ m/s^2$ ⓒ $4.5\ m/s^2$ ⓓ $5\ m/s^2$

(iii) The displacement of the body after 20 s equals ....

ⓐ 145 m ⓑ 560 m ⓒ 600 m ⓓ 620 m

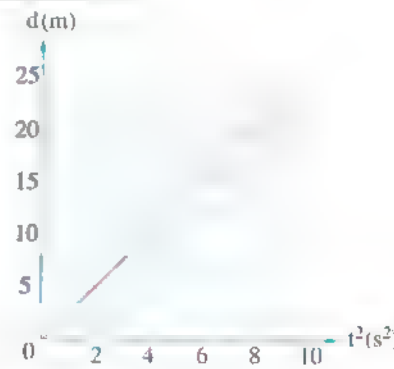
(iv) The distance covered by the body when it reaches a velocity of 20 m/s equals ....

ⓐ 72.8 m ⓑ 36.4 m ⓒ 36.3 m ⓓ 18.2 m

(v) The velocity of the body after 15 s equals ....

ⓐ 21.7 m/s ⓑ 42.5 m/s ⓒ 43.5 m/s ⓓ 50 m/s

32 ✳ The opposite graph of displacement (d) versus time squared (t^2) represents the motion of a body with a uniform acceleration, then its velocity after 10 s from starting this motion equals ....



ⓐ 25 m/s ⓑ 50 m/s

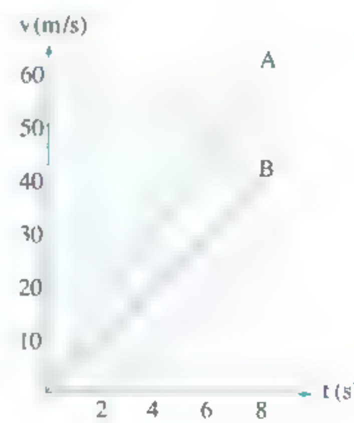
ⓒ 100 m/s ⓓ 2.5 m/s

33 ✳ The opposite graph of velocity squared (v^2) versus displacement (d) represents the motion of a body with a uniform acceleration. What is the acceleration and the time of observing this motion?

ⓐ -5 m/s^2, 1.55 s ⓑ -3.33 m/s^2, $\sqrt{2}$ s

ⓒ -5 m/s^2, 5.01 s ⓓ $\sqrt{5}$ m/s^2, $\sqrt{3}$ s

34 ✳ The opposite graph represents the relation between the velocity and the time for two bodies A and B that move from rest in a straight line, then:



(i) The displacement of body A after 6 s equals ....

ⓐ 270 m ⓑ 150 m

ⓒ 135 m ⓓ 120 m

(ii) The displacement of body B after 6 s equals ....

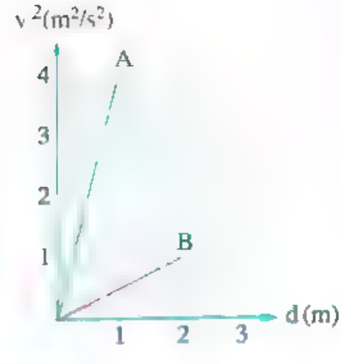
ⓐ 180 m ⓑ 90 m

ⓒ 75 m ⓓ 15 m

(iii) The time taken by body B to cover the same displacement of body A after 6 s equals ....

ⓐ 6.92 s ⓑ 7.35 s ⓒ 7.74 s ⓓ 7.92 s

35 ✱ The opposite graph represents the relation between the square of the velocity (v^2) and the displacement (d) for two bodies A and B that start their motions from rest, so the ratio between the final velocities of A and B ($\frac{v_A}{v_B}$) after passing 5 s is ....



ⓐ $\frac{8}{1}$ ⓑ $\frac{4}{1}$

ⓒ $\frac{1}{8}$ ⓓ $\frac{1}{4}$

36 ✱ A body starts its motion from rest with a constant acceleration in a straight line. If its average velocity during 8 s starting from the beginning of the motion equals 1.5 m/s, so its instantaneous velocity after 30 s from starting the motion equals ....

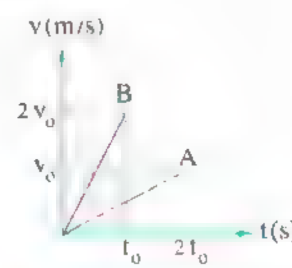
ⓐ 15.4 m/s ⓑ 12.5 m/s ⓒ 11.25 m/s ⓓ 9.25 m/s

Second Essay questions

1 If the displacement (d) covered by a body during a time interval t is given by the relation; $d = \frac{1}{2} at^2$, where (a) is the acceleration of the body.

Mention the conditions that makes the previous relation applicable for the motion of a body.

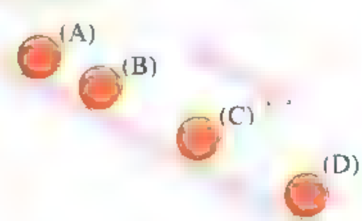
2 The opposite figure represents the graph of velocity versus time for two objects A and B that started their motions from rest in a straight line.



(a) **Which** object has moved with a greater acceleration? **And why**?

(b) **Which** object has covered a greater distance? **And why**?

3 The opposite figure illustrates a ball rolling down from rest a smooth inclined plane with a uniform acceleration. Points (A, B, C and D) indicate the ball position every 0.5 s.



Based on the figure, answer the following:

(a) **How can** you deduce from the figure that the ball is speeding up?

(b) **Calculate** the ball's acceleration if the distance between (A) and (D) is 2 m.

4 An object starts its motion in a straight line from position x_i with an initial velocity v_i moving with a uniform acceleration. **Prove that** its final position (x_f) can be determined from the relation; $x_f = x_i + \frac{1}{2}(v_i + v_f)\,t$

Questions that measure high levels of thinking

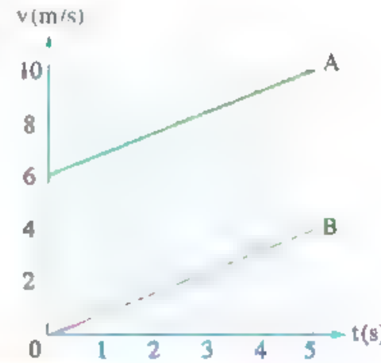
Answered in detail

Choose the correct answer :

1. A runner traverses a straight racetrack of length 100 m in 17 s, where he moves the first 3 seconds with a uniform acceleration a for a distance d to reach a velocity v and after covering this distance he continues the rest of the race by this velocity (v), so the values of a and d respectively are ....

   (a) $0.8\ m/s^2$, 3.63 m (b) $0.8\ m/s^2$, 9.68 m
   (c) $2.15\ m/s^2$, 3.63 m (d) $2.15\ m/s^2$, 9.68 m

2. The opposite graph represents the change in the velocities of two bodies A and B versus time, so the difference between their displacements equals ....



   (a) 10 m
   (b) 50 m
   (c) 30 m
   (d) 60 m

3. Two cars start their motions from rest at the same starting point and move in the same direction as in the opposite figure, if the distance between them becomes 200 m after time t, then the distance between them after time 2 t will be ....

   (a) 200 m (b) 400 m (c) 800 m (d) 1600 m

4. A tiger started running when it saw a deer running at uniform velocity of 2 m/s at 15 m far from it. If the tiger ran at acceleration of $2\ m/s^2$ in the same straight line, then the tiger catches the deer after:

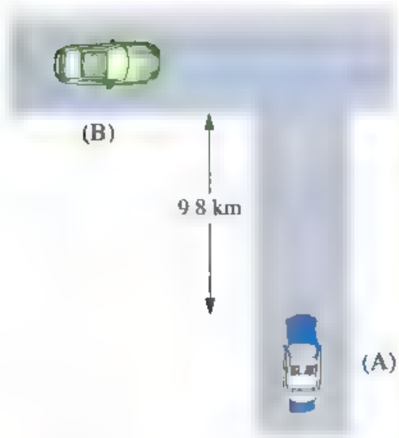
   (i) passing a time of .... from starting the motion.

   (a) 5 s (b) 4 s (c) 2.5 s (d) 1 s

   (ii) covering a distance of ....

   (a) 25 m (b) 15 m (c) 10 m (d) 5 m

5 In the opposite figure, a static police car (A) that was at a distance of 9.8 km from the junction of two roads received a report about car (B) that is moving with uniform velocity of 40 m/s on this road. If the police car moved with an acceleration of 4 m/s^2 immediately to stop car (B), hence it reached the junction before car (B) by 30 s, so at what distance was car (B) from the junction when the policeman received the report?

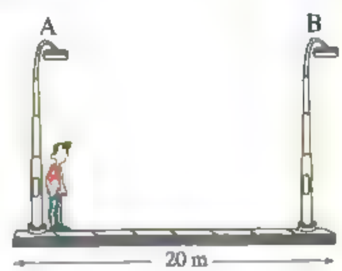


ⓐ 8 km ⓑ 4 km
ⓒ 3 km ⓓ 2 km

6 The opposite figure shows a car that was moving with uniform velocity on a straight road, the car's driver suddenly saw a truck broken down at 45 m apart from him, so he applied the brakes to decelerate the car by 2.77 m/s per second, but the car in the end collided with the truck with a velocity of 5.35 m/s so the time elapsed between applying the brakes and colliding with the truck equals ....

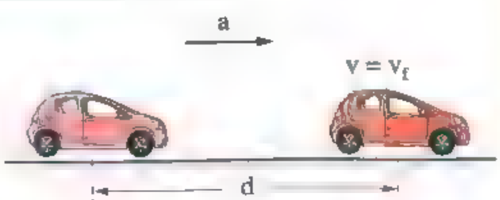
ⓐ 2 s ⓑ 4 s ⓒ 6 s ⓓ 8 s

7 The man in the opposite figure starts his motion from rest with an acceleration of 0.5 m/s^2 at lamppost A till his velocity reaches 2 m/s, then he moves uniformly by this velocity until he reaches lamppost B, so the total time of the man's motion is ....



ⓐ 4 s ⓑ 8 s
ⓒ 12 s ⓓ 16 s

8 The opposite figure shows a car moving with uniform acceleration a to cover a displacement d over a time interval t. If the velocity of the car at the end of this interval is v_f, so which of the following relations is correct?



ⓐ $d = -\frac{1}{2} at^2$ ⓑ $d = 2 v_f t - at^2$
ⓒ $d = v_f t - \frac{1}{2} at^2$ ⓓ $d = \frac{1}{2} (v_f t + at^2)$

9. A car was moving with uniform acceleration in a straight line. If the velocity at a certain moment was 30 m/s and after 5 s from this moment its velocity became 10 m/s, then the distance covered through the third second only of this interval equals ....

ⓐ 32 m ⓑ 28 m ⓒ 22 m ⓓ 20 m

Answer the following questions :

10. **Explain why the following situation is impossible:**

"A body starts its motion from rest in a straight line with uniform acceleration to cover a distance of 50 m through 10 s till its final velocity after this time equals 8 m/s".

How

the separating distances between water drops that fall from a tap change as they move downwards?

Chapter **2**

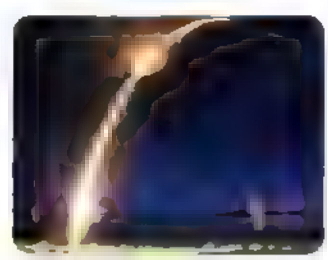
Lesson Two

Applications of Motion with Uniform Acceleration (Free Fall - Vertical Projectiles)

◎ In the previous lesson, we talked about the equations of motion that describe the motion of objects at uniform acceleration and now we will study some applications of motion with uniform acceleration, such as:

Free fall

Projectiles



Free fall

◎ When a rock and a feather are dropped from the same height at the same moment inside a tube filled with air, we notice that the rock reaches the bottom of the tube first (figure (1)) where the two bodies during falling are under the effect of two forces:

1. **The gravitational pull of the Earth (their weights).**
2. **The air resistance to their motion,**
   since the collisions of air molecules with the object affect the velocity of falling of light objects (the feather) more than that of heavier objects (the rock), we find that the rock reaches the bottom of the tube first.

Figure (1)

Figure (2)

- If we repeat the previous experiment but with evacuating the tube from air, we notice that the rock and the feather reach the bottom of the tube at the same moment (figure 2) which means that when they fall under the effect of their weights only, they move with the same acceleration.

- The motion of bodies in the gravitational field under the effect of their weights only with neglecting the air resistance is called free fall and the experiments prove that the free falling bodies move with the same uniform acceleration regardless of their masses which is called free fall acceleration whose average value at the Earth's surface is 9.8 m/s^2 and its direction is towards the center of the Earth.

- When studying the motion of any body in free fall, we should assume a reference (positive) direction of motion and relative to it the sign of the acceleration is determined and in the following we will assume that the positive direction of motion is the direction of the initial velocity of the body.

Note:

- **The free fall acceleration varies slightly from one place to another on the Earth's surface** because the Earth's shape is not completely spherical but it is ellipsoid, where its equatorial diameter is bigger than its polar diameter, so the free fall acceleration varies depending on the distance from the Earth's center, but we will neglect this slight variation during our study.

Distinguished Scientists

Galileo

Galileo proved that:

Falling objects of different masses, when neglecting air resistance, reach the ground at the same time.

He put an end for Aristotle's idea that implied. "Heavy objects would reach the ground in shorter time interval than that taken by lighter objects".

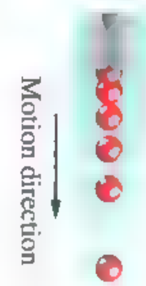
He proved this by dropping two objects of different masses and equal volumes down the leaning Tower of Pisa in Italy.

Notes:

(1) When objects move under the effect of gravity, the equations of motion with uniform acceleration are applied using letter "g" instead of "a" for denoting the acceleration due to gravity as follows:

$$v_f = v_i + gt \quad , \quad d = v_i t + \frac{1}{2}gt^2 \quad , \quad 2gd = v_f^2 - v_i^2$$

(2) The opposite figure represents a recording for the positions of a body that falls freely from rest through equal intervals of time and the following table shows the instantaneous velocity of this body at each second and the distance covered by it away from the falling position (consider $g = 10\ m/s^2$).



The instantaneous velocity (m/s)	The falling distance (m)	The time taken (s)
0	0	0
10	5	1
20	20	2
30	45	3
40	80	4
50	125	5
gt	$\frac{1}{2}gt^2$	t

We notice that:

- The velocity of the body increases uniformly with time where $v_f \propto t$ according to the first equation of motion ($v_f = v_i + gt$), so we find that the instantaneous velocity of the body at the end of the 1st second ($t = 1$ s) is 10 m/s and its instantaneous velocity at the end of the 2nd second ($t = 2$ s) is 20 m/s.
- The displacement of the body increases non-uniformly with time where $d \propto t^2$ according to the second equation of motion ($d = \frac{1}{2} gt^2$), so we find that the displacement of the body is 5 m during the 1st second and its displacement is 15 m during the 2nd second only (20 m during the two seconds).

Example 1

An apple fell freely from a tree and hit the ground after 1 second, then: *($g = 10\ m/s^2$)*

(i) The velocity of the apple at the moment of hitting the ground equals ....

ⓐ 7 m/s ⓑ 8 m/s ⓒ 9 m/s ⓓ 10 m/s

(ii) The average velocity of the apple through its fall till reaching the ground equals ....

ⓐ 1 m/s ⓑ 3 m/s ⓒ 5 m/s ⓓ 7 m/s

Solution

$v_i = 0$ $g = 10\ m/s^2$ $t = 1\ s$ $v_f = ?$ $\bar{v} = ?$

Assume that the positive direction of motion is downwards.

(i) $v_f = v_i + g\,t = 0 + (10 \times 1) = 10\ m/s$

∴ **The correct choice is ⓓ.**

(ii) $\bar{v} = \frac{v_f + v_i}{2} = \frac{10 + 0}{2} = 5\ m/s$

∴ **The correct choice is ⓒ.**

What if we want to calculate the height from which the apple fell above the ground, **what** will be your answer?

Example 2

A stone fell from the top of a building. If the stone passed by a man standing in a balcony that was 5 m high above the ground 2 s later (consider: $g = 10\ m/s^2$), then:

(i) The building height equals ....

ⓐ 13 m ⓑ 19 m ⓒ 25 m ⓓ 31 m

(ii) The stone velocity at the moment of passing by the man equals ....

ⓐ 10 m/s ⓑ 15 m/s ⓒ 20 m/s ⓓ 25 m/s

Solution

$v_i = 0$ $d_1 = 5\ m$ $g = 10\ m/s^2$ $t = 2\ s$ $h = ?$, $v_f = ?$

Clue

The height of the building is the distance covered by the stone from the top of the building to the balcony (d_2) added to the height of the balcony above the ground (d_1).

Assume that the reference (positive) direction of motion is downwards.

(i) $d_2 = v_i t + \frac{1}{2} g t^2 = 0 + (\frac{1}{2} \times 10 \times (2)^2) = 20$ m

$h = d_1 + d_2 = 5 + 20 = 25$ m

$\therefore$ **The correct choice is ⓒ.**

(ii) $v_f = v_i + g t = 0 + (10 \times 2) = 20$ m/s

$\therefore$ **The correct choice is ⓒ.**

What if we want to calculate the velocity of the stone at the moment of reaching the ground, **what** will be your answer?

Example 3

The opposite figure represents a boy holding a ball. If the ball is dropped to fall freely from rest, then the ratio between the instantaneous velocity of the ball when it passes by point y and its instantaneous velocity when it passes by point k is ....

ⓐ $\frac{1}{3}$

ⓑ $\frac{1}{2}$

ⓒ $\frac{1}{\sqrt{3}}$

ⓓ $\frac{1}{\sqrt{2}}$

Solution

$v_f^2 = v_i^2 + 2 g d$

$\because v_i = 0$

$\therefore v_f^2 = 2 g d$

$$\therefore \frac{(v_f)_y^2}{(v_f)_k^2} = \frac{d_{xy}}{d_{xk}} = \frac{d}{3 d} = \frac{1}{3}$$

$$\therefore \frac{(v_f)_y}{(v_f)_k} = \frac{1}{\sqrt{3}}$$

Integration with Mathematics

You can revise the direct proportionality from section (7) page (12).

$\therefore$ **The correct choice is ⓒ.**

What if we want to determine the ratio between the time taken by the ball to reach point y and the time taken by the ball to reach point ℓ from the start of motion $(\frac{t_y}{t_\ell})$, **what** will be your answer?

Example 4

The following table records the values of velocity (v), displacement (d) and time (t) of a freely falling object:

t (s)	d (m)	v (m/s)
0	0	0
0.5	1.25	5
1	5	10
1.5	11.25	15
2	20	20

(i) **Use the recorded data to plot** the graphs of displacement versus time and velocity versus time that describe the motion of the object.

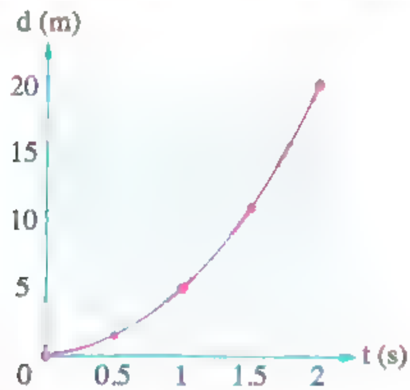
(ii) **What** can be concluded from the increase in spacing between the object positions at equal intervals as time passes?

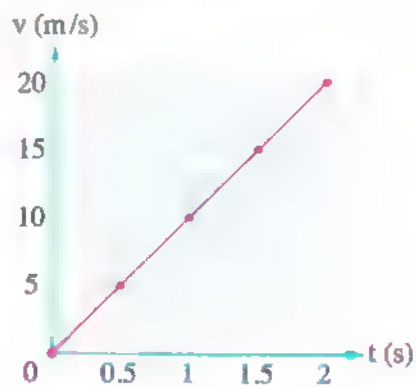
(iii) **Calculate** the displacement and the velocity of the object after 3 s from the moment of its falling.

Solution

Assume that the reference (positive) direction of motion is downwards.

(i)





(ii) The increase in spacing between the object positions at equal intervals as time passes indicates that the object moves at increasing velocity (positive acceleration) which means that the velocity and the acceleration of the body are in the same direction.

(iii) From the (velocity-time) graph:

$$g = \text{Slope} = \frac{\Delta v}{\Delta t} = \frac{20-0}{2-0} = 10 \text{ m/s}^2$$

$$d = v_i t + \frac{1}{2} g t^2$$

$$= 0 + \frac{1}{2} \times 10 \times (3)^2 = 45 \text{ m}$$

$$v_f = v_i + g t = 0 + (10 \times 3) = 30 \text{ m/s}$$

Practical Experiment

Determining the free fall acceleration (the acceleration due to gravity)

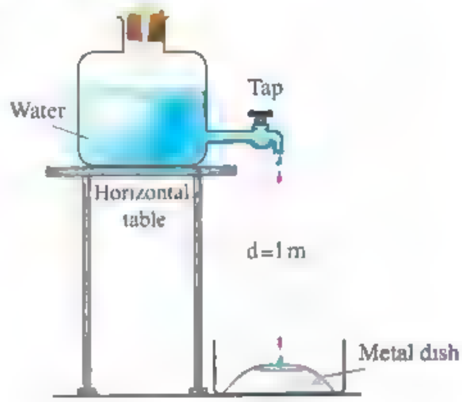
1. Experiment Objective:

Determining the free fall acceleration (the acceleration due to gravity g).

2. Experiment Idea:

- Measuring the time (t) taken by a water drop to fall freely through a vertical displacement (d).
- Finding the free fall acceleration (g) by knowing both of (t) and (d) and applying the second law of motion.

3. Tools:



1. A jar of water provided with a tap that controls water dripping.
2. A stopwatch.
3. A metal dish to produce sounds of water splashes.
4. Meter tape.

4. Procedure:

1. Adjust the metal dish directly below the tap opening at a distance (d = 1 m).
2. Control the tap to allow a water drop to fall just at the instant of hearing the previous drop hitting the dish base, accordingly the time taken by the drop to fall becomes equal to the time between dripping two successive drops from the tap.
3. Record the time taken by 50 successive drops to drip using the stopwatch.
   Then, find the time between two successive drops (t) which is the time of drop falling.

$$t = \frac{\text{Total time}}{\text{Number of drops}}$$

4. Repeat the previous step several times then find the average time taken by one drop to fall.
5. Find the acceleration due to gravity (g) using the second equation of motion, where:

$$d = v_i t + \frac{1}{2} at^2$$

$$\because v_i = 0 \quad , \quad a = g$$

$$\therefore d = \frac{1}{2} gt^2 \quad \therefore \quad g = \frac{2d}{t^2}$$

Example

In an experiment to determine the acceleration due to gravity using freely falling water drops, the distance between the tap nozzle and the plate base was 1 m. If the time taken by 100 successive drops is 45 s to fall and reach the plate, then the acceleration due to gravity is ....

ⓐ $9.75\ m/s^2$ ⓑ $9.80\ m/s^2$ ⓒ $9.88\ m/s^2$ ⓓ $10\ m/s^2$

Solution

$v_i = 0$ $d = 1\ m$ $t_{100} = 45\ s$ $n = 100$ $g = ?$

Assume that the positive direction of motion is downwards.

Time taken by one drop to fall (t) $= \frac{\text{Total time}}{\text{Number of drops}} = \frac{t_{100}}{n} = \frac{45}{100} = 0.45\ s$

$\because d = v_i t + \frac{1}{2} g t^2 = \frac{1}{2} g t^2$

$\therefore g = \frac{2d}{t^2} = \frac{2 \times 1}{(0.45)^2} = 9.88\ m/s^2$

$\therefore$ **The correct choice is ⓒ.**

Test yourself

Answered

Choose the correct answer:

1 Which of the following statements is correct for a body that is falling freely with a constant acceleration $9.8\ m/s^2$?

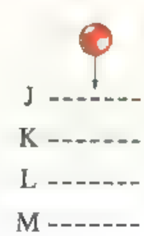
ⓐ The body falls a distance of 9.8 m after passing the first second.

ⓑ The body falls a distance of 9.8 m every second.

ⓒ The acceleration of the body changes by $9.8\ m/s^2$ every second.

ⓓ The average velocity of the body during the first second is 4.9 m/s.

2 A metallic ball falls freely through 4 levels J, K, L and M that are at equal distances from each other as in the opposite figure, then ....



	The highest average velocity of the ball is between the two levels	The least time taken by the ball is between the two levels
ⓐ	J, K	J, K
ⓑ	J, K	L, M
ⓒ	L, M	J, K
ⓓ	L, M	L, M

Projectiles

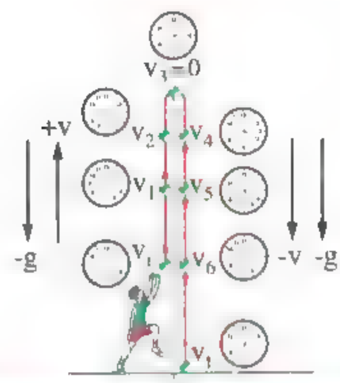
First: Vertical projectiles

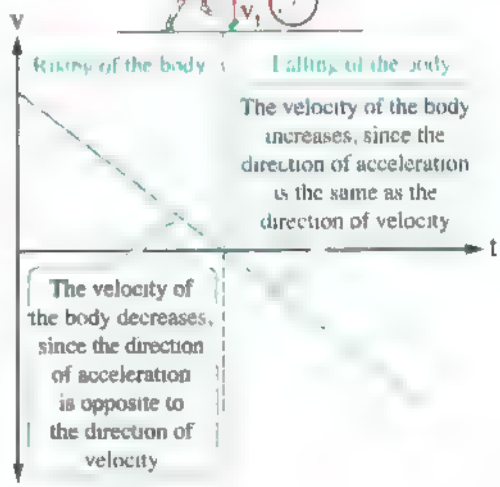
Second: Projectiles at an angle

First Vertical projectiles

- The motion of the bodies that move under the effect of the acceleration due to gravity only is called free fall regardless the direction of motion of the body or its initial velocity.

- When a body is projected vertically upwards at initial velocity v_i by neglecting the air resistance, it will move with the free fall acceleration and the direction of the acceleration will be opposite to the direction of motion (velocity), so the velocity of the body decreases gradually as the body gets higher till its velocity reaches zero at the maximum height reached by the body.





- At the maximum height, the body stops for an instant and then it starts to fall which means it reverses its direction of motion and it moves towards the Earth's surface with the acceleration due to gravity and in the same direction of acceleration, so the velocity of the body increases gradually as it approaches to the Earth's surface where:

The velocity of the object when it is projected upwards	=	– its velocity at the same level (height) when it is falling down
The time of rising to the maximum height	=	The time of falling to the same level of projection

Note:

- When a body is projected vertically upwards, its velocity decreases uniformly till it vanishes at the maximum height and the body becomes at rest at that moment but its acceleration at this moment doesn't equal zero and it is equal to the free fall acceleration.

Example 1

An object is projected vertically upwards at initial velocity of 98 m/s from the ground, then: *($g = 9.8\ m/s^2$)*

(i) The maximum height reached by the object is ....

ⓐ 490 m ⓑ 530 m ⓒ 575 m ⓓ 611 m

(ii) The time taken to reach that height is ....

ⓐ 2.5 s ⓑ 5 s ⓒ 7.5 s ⓓ 10 s

Solution

$v_i = 98\ m/s$ $v_f = 0$ $g = 9.8\ m/s^2$ $d = ?$ $t = ?$

Assume that the positive direction of motion is upwards.

(i) $v_f^2 - v_i^2 = -2\,gd$

$$d = \frac{v_f^2 - v_i^2}{-2\,g} = \frac{0 - (98)^2}{-2 \times 9.8} = 490\ m$$

∴ **The correct choice is ⓐ.**

(ii) $v_f = v_i - gt$

$$t = \frac{v_f - v_i}{-g} = \frac{0 - 98}{-9.8} = 10\ s$$

∴ **The correct choice is ⓓ.**

What if we want to calculate the time taken by the object to return to the ground from the moment of projection, **what** will be your answer?

Example 2

A ball is projected vertically downwards with initial velocity 8 m/s from a height of 30 m, then the time taken by the ball to reach the ground is .... *($g = 9.8\ m/s^2$)*

ⓐ 0.87 s ⓑ 1.79 s ⓒ 3.14 s ⓓ 5.22 s

Solution

$v_i = 8\ m/s$ $d = 30\ m$ $g = 9.8\ m/s^2$ $t = ?$

Assume that the positive direction of motion is downwards.

$v_f^2 = v_i^2 + 2\,gd = (8)^2 + (2 \times 9.8 \times 30)$

$v_f = 25.53\ m/s$

$v_f = v_i + gt$

$25.53 = 8 + 9.8\,t$

$t = 1.79\ s$

Another Solution:

$d = v_i t + \frac{1}{2} g t^2$

$30 = 8t + (\frac{1}{2} \times 9.8 \times t^2)$

$4.9 t^2 + 8t - 30 = 0$

By using the calculator to solve the equation:

$\therefore t = 1.79$ s

$\therefore$ **The correct choice is ⓑ.**

Integration with Mathematics

You can revise how to solve second degree equation with one unknown from section (9) page (15).

What if the ball is projected vertically upwards with the same initial speed, **what** will be the time taken by the ball to reach the ground?

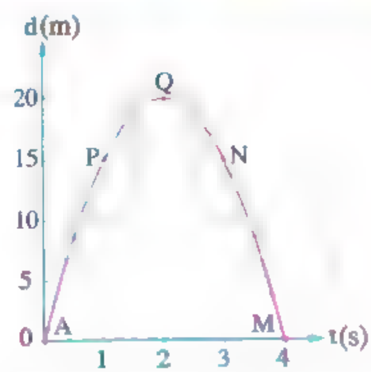
Example 3

The table below records time, displacement and velocity of an object projected vertically upwards at initial velocity 20 m/s:

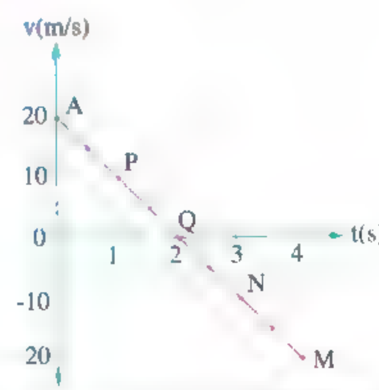
Time (s)	0	0.5	1	1.5	2	2.5	3	3.5	4
Displacement (m)	0	8.75	15	18.75	20	18.75	15	8.75	0
Velocity (m/s)	20	15	10	5	0	– 5	– 10	– 15	– 20

This motion can be represented by the following diagrams.

Projectile trajectory



Change of displacement with time



Change of velocity with time

(a) **Determine** the object velocity at the points P, Q and N from the (displacement-time) graph and from the (velocity-time) graph.

(b) **What** is the value of the line slope in the (velocity-time) graph? **What** does it represent? **Why** has it got a negative sign?

(c) **Calculate** the distance and displacement from the start to the end of the journey.

Solution

(a) From the (displacement-time) graph:

The velocity of the body at any point equals the slope of the tangent of the curve at that point.

$$\text{Slope} = \frac{\Delta d}{\Delta t} = v$$

$$v_P = \frac{\Delta d}{\Delta t} = \frac{20-10}{1.5-0.5} = 10 \text{ m/s}$$

$$v_Q = 0$$

$$v_N = \frac{\Delta d}{\Delta t} = \frac{10-20}{3.5-2.5} = -10 \text{ m/s}$$

From the (velocity-time) graph, we obtain the same values.

(b) Slope of line $= \frac{\Delta v}{\Delta t} = \frac{0-20}{2-0} = -10 \text{ m/s}^2$

The slope of line represents the acceleration of the object (free fall acceleration). The negative sign indicates that the object velocity decreases as it goes further from the ground.

(c) Distance (s) $= 20 + 20 = 40$ m

Displacement (d) = zero

Example 4

A ball is projected vertically upwards with initial velocity v to reach maximum height h after time t. If it is projected vertically upwards with initial velocity 2 v, then the maximum height reached by the ball would be ....

ⓐ $\sqrt{2}$ h ⓑ 2 h ⓒ 4 h ⓓ 16 h

Solution

Assume that the positive direction of motion is upwards.

$$v_f^2 = v_i^2 + 2ad \quad , \quad v_f = 0$$

$$-v_i^2 = -2gd$$

$$\frac{d_1}{d_2} = \frac{(v_i)_1^2}{(v_i)_2^2} \quad , \quad \frac{h}{d_2} = \frac{v^2}{(2v)^2} = \frac{1}{4}$$

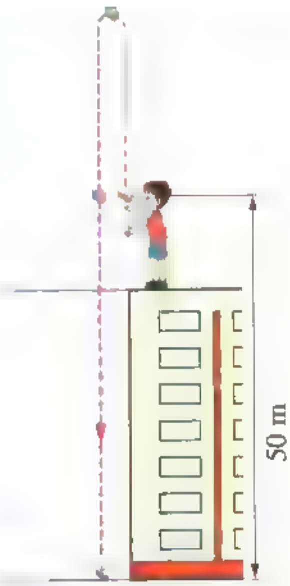
$$d_2 = 4h$$

∴ The correct choice is ⓒ.

What if the ball is projected vertically upwards with initial velocity 3 v, what will be the time taken by it to reach the maximum height in terms of t?

Example 5

The opposite figure shows a boy that throws a stone vertically upwards from the top of a building with velocity 20 m/s. If the height of the stone from the ground at the moment of projection is 50 m, then: *($g = 9.8\ m/s^2$)*



The ground

(i) The time taken by the stone to reach the maximum height is ....

ⓐ 1.12 s ⓑ 2.04 s

ⓒ 3.08 s ⓓ 5.07 s

(ii) The maximum height (h_2) reached by the stone from the point of projection is ....

ⓐ 13.8 m ⓑ 15.9 m

ⓒ 20.4 m ⓓ 23.7 m

(iii) The magnitude of the velocity of the stone when it returns to its point of projection is ....

ⓐ 10 m/s ⓑ 15 m/s

ⓒ 18 m/s ⓓ 20 m/s

(iv) The magnitude of the velocity of the stone and its displacement after 5 s from the moment of projection are ....

	The magnitude of the velocity of the stone	The displacement of the stone
ⓐ	29 m/s	22.5 m downwards
ⓑ	29 m/s	17.25 m upwards
ⓒ	25 m/s	22.5 m downwards
ⓓ	25 m/s	17.25 m upwards

Solution

$v_i = 20$ m/s $h_1 = 50$ m $g = 9.8\ m/s^2$ $t = ?$ $h_2 = ?$ $v_f = ?$ $d = ?$

Assume that the positive direction of motion is upwards.

(i) When the stone reaches the maximum height:

$v_f = v_i + a\,t = v_i - gt$

$0 = 20 - 9.8\,t$

$t = 2.04$ s

∴ **The correct choice is ⓑ.**

(ii) $h_2 = v_i t + \frac{1}{2} a t^2$

$= v_i t - \frac{1}{2} g t^2$

$= (20 \times 2.04) - (\frac{1}{2} \times 9.8 \times (2.04)^2) = 20.4 \text{ m}$

$\therefore$ **The correct choice is ⓒ.**

(iii) The magnitude of the velocity of the stone when it returns to its projection point = The magnitude of the velocity of the stone at the moment of projection = 20 m/s

$\therefore$ **The correct choice is ⓓ.**

(iv) $v_f = v_i + at$

$= v_i - gt$

$= 20 - (9.8 \times 5) = -29 \text{ m/s}$

$d = v_i t + \frac{1}{2} a t^2$

$= v_i t - \frac{1}{2} g t^2$

$= (20 \times 5) - (\frac{1}{2} \times 9.8 \times (5)^2) = -22.5 \text{ m}$

$\therefore$ **The correct choice is ⓐ.**

What If the height of the stone from the ground at the moment of projection is 30 m, **which** of the calculated values will change?

2 *Test yourself*

Answered

1 **Choose the correct answer:** A rock is ejected from the opening of a volcano vertically upwards with velocity 30 m/s, then its velocity when it returns back to the opening of the volcano is ....

ⓐ equal to 30 m/s ⓑ equal to – 30 m/s

ⓒ greater than – 30 m/s ⓓ 0

2 A ball is projected vertically upwards to reach the maximum height (h) after 3 s, **then calculate** the value of h. $(g = 10 \text{ m/s}^2)$

....

....

....

Chapter 2

Questions on Lesson Two

Applications of Motion with Uniform Acceleration (Free Fall - Vertical Projectiles)

To watch videos of how to solve questions use the App

GPS

Interactive test

The questions signed by ✳ are answered in detail.

First Multiple choice questions

Free fall

1. When an object falls freely, its .... changes from one point to another.
   (a) mass (b) velocity (c) acceleration (d) density

2. Two bodies of different materials having the same volume fall freely together from the same height, neglecting the air resistance, which of the following statements is correct?
   (a) The heavier body reaches the ground first.
   (b) The lighter body reaches the ground first.
   (c) The heavier body accelerates more.
   (d) They reach the ground at the same time.

3. If a body falls freely from a building of height (d) where it takes time (t) to reach the base of the building, then the height of the building is given by the relation: ....
   (a) $d = gt$ (b) $d = gt^2$ (c) $d = \frac{1}{2} gt$ (d) $d = \frac{1}{2} gt^2$

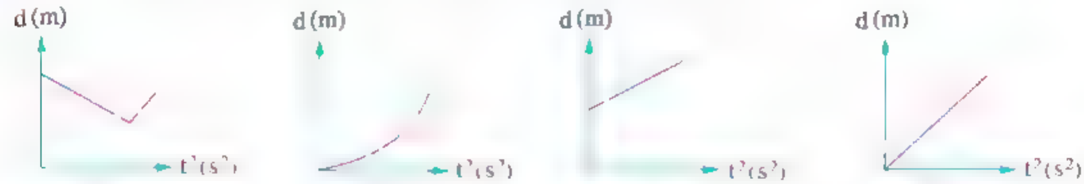
4. An object falls freely. Given that ($g = 9.8$ m/s^2), its velocity 3 seconds later becomes ....
   (a) 29.4 m/s (b) 98 m/s (c) 19.6 m/s (d) 9.8 m/s

5. ✳ Two spherical bodies of masses 5 kg and 2.5 kg that have equal volumes fall freely from a point 10 m high above the ground, then the time taken by each body to reach the ground is .... respectively. ($g = 9.8$ m/s^2)
   (a) 1.43 s, 1.43 s (b) 1.43 s, 0.48 s (c) 1.01 s, 1.01 s (d) 1.01 s, 0.34 s

6. ✳ An object falls freely from a point that is 3.2 m high above the Moon's surface. If it takes 2 s to reach the surface, then the acceleration due to Moon's gravity equals ....
   (a) 3.2 m/s^2 (b) 1.6 m/s^2 (c) 0.8 m/s^2 (d) 0.4 m/s^2

7. ✳ An object falls freely from 5 m high point above the ground, then: ($g = 9.8$ m/s^2)
   (i) The velocity of the object when it reaches the ground is ....
   (a) 9.9 m/s (b) 7 m/s (c) 4.95 m/s (d) 4.4 m/s
   (ii) The time taken by the object to reach the ground is ....
   (a) 1.01 s (b) 0.98 s (c) 0.7 s (d) 0.45 s

8 The graph that represents the relation between the displacement (d) and the square of the time (t^2) for an object that falls freely from rest is ....

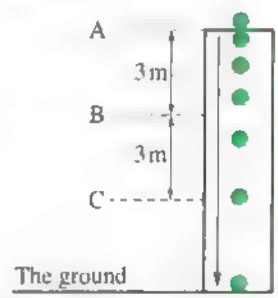


(a) (b) (c) (d)

9 ✳ In an experiment to determine the acceleration due to gravity using water drops that fall freely, the distance between the tap nozzle and the plate base is 1 m. If the time taken by 100 successive drops to hit the plate is 45 s, then the free fall acceleration according to the results of the experiment equals ....

(a) 9.7 m/s^2 (b) 9.8 m/s^2 (c) 9.88 m/s^2 (d) 10 m/s^2

10 ✳ The opposite figure shows a ball in a free fall starting from position A, so the ratio between the velocity of the ball at position B and at position C ($\frac{v_B}{v_C}$) equals .... ($g = 10\ m/s^2$)



(a) $\frac{1}{4}$ (b) $\frac{1}{2}$

(c) $\frac{1}{\sqrt{3}}$ (d) $\frac{1}{\sqrt{2}}$

11 ✳ A ball falls from a height h above the Moon surface to reach the Moon surface after time t_1 with velocity v_1 and another ball falls from an equal height h above the Earth surface to reach the Earth surface after time t_2 with velocity v_2, so which of the following choices is correct?

(Knowing that: The free fall acceleration on Earth is 6 times the free fall acceleration on Moon)

	The relation between v_1 and v_2	The relation between t_1 and t_2
(a)	$v_1 > v_2$	$t_1 > t_2$
(b)	$v_1 > v_2$	$t_1 < t_2$
(c)	$v_1 < v_2$	$t_1 > t_2$
(d)	$v_1 < v_2$	$t_1 < t_2$

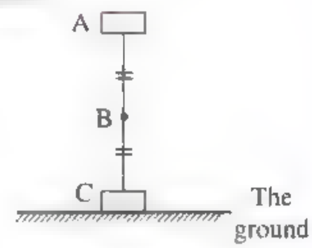
12 ✳ If a body falls freely such that its velocity after covering a distance of 1 m from the start of its motion is v m/s, then its velocity after 1 s from the start of its motion is .... m/s.

(a) v^2 (b) 2 v (c) $\frac{v^2}{2}$ (d) $\sqrt{2}$ v

13 ✻ A piece of lead was dropped from 10 m high above a lake surface, then it hit the surface of lakewater at velocity v to dive into water with an average velocity that equals 0.1 v till reaching the bottom of the lake after 6.5 s from the instant of hitting the surface of water, then the depth of the lake equals .... ($g = 10\ m/s^2$)

(a) 91.91 m (b) 65 m (c) 9.19 m (d) 6.5 m

14 ✻ An object falls freely as in the opposite figure from point (A) to point (C) passing through point (B) at the middle of the distance, then the ratio between the time of motion of the object from (A) to (B) and the time of motion from (A) to (C) equals ....



(a) $\frac{2}{1}$ (b) $\frac{\sqrt{2}}{1}$ (c) $\frac{1}{\sqrt{2}}$ (d) $\frac{1}{2}$

Vertical projectiles

15 Body A falls freely from height h towards the ground and at the same instant. Body B is projected vertically upwards from the ground. If the two bodies meet at height $\frac{h}{3}$, then the ratio between the accelerations of the two bodies $\left(\frac{a_A}{a_B}\right)$ is ....

(a) $\frac{a_A}{a_B} > 1$ (b) $\frac{a_A}{a_B} = 1$ (c) $\frac{a_A}{a_B} < 1$ (d) $\frac{a_A}{a_B} = 0$

16 Two solid balls of the same volume, one of them is metallic and the other is wooden, are projected vertically upwards from the same level with the same initial velocity, given that the density of the metal is higher than the density of the wood, then ....

(a) the two balls return to the level of projection together

(b) the metallic ball returns to the level of projection first

(c) the wooden ball returns to the level of projection first

(d) we can't determine the answer

17 When projecting a body vertically upwards, then:

(1) During ascent ....

	The direction of velocity	The direction of acceleration
(a)	downwards	downwards
(b)	downwards	upwards
(c)	upwards	downwards
(d)	upwards	upwards

(ii) During falling ....

	The direction of velocity	The direction of acceleration
(a)	downwards	downwards
(b)	downwards	upwards
(c)	upwards	downwards
(d)	upwards	upwards

18 If a body is projected vertically upwards assuming that the positive direction of motion is upwards, then which of the following choices is correct at the maximum height reached by the body?

	Body's velocity	Body's acceleration
(a)	0	g
(b)	0	– g
(c)	Maximum	g
(d)	Maximum	– g

19 ✳ The maximum height for a jump recorded by a player in a basketball game was 1 m, so the flight time of this player in air is .... ($g = 10\ m/s^2$)

(a) $\frac{\sqrt{5}}{2}$ s (b) $\sqrt{5}$ s (c) $2\sqrt{5}$ s (d) $\frac{2\sqrt{5}}{5}$ s

20 ✳ A body is projected vertically upwards to reach maximum height of 80 m, then: ($g = 9.8\ m/s^2$)

(i) The velocity of projection is ....

(a) 39.6 m/s (b) 28 m/s (c) 19.8 m/s (d) 14 m/s

(ii) The time taken by the body to return to the point of projection is ....

(a) 2.85 s (b) 4.04 s (c) 5.71 s (d) 8.08 s

21 ✳ A body was projected vertically upwards with initial velocity 98 m/s, then: ($g = 9.8\ m/s^2$)

(i) The velocity of the body after 5 s from the moment of projection equals ....

(a) 147 m/s (b) 93 m/s (c) 49 m/s (d) 24.5 m/s

(ii) The maximum height reached by the body is ....

(a) 980 m (b) 490 m (c) 414 m (d) 397 m

(iii) The total time taken by the body from the moment of projection till it returns again to the point of projection is ....

ⓐ 10 s ⓑ 18.9 s ⓒ 19.7 s ⓓ 20 s

22 ✳ An object is projected vertically upwards with initial velocity of 60 m/s, then: ($g = 10\ m/s^2$)

(i) The time taken by the object to reach a velocity of 20 m/s as it ascends equals ....

ⓐ 8 s ⓑ 4 s ⓒ 2 s ⓓ 0.25 s

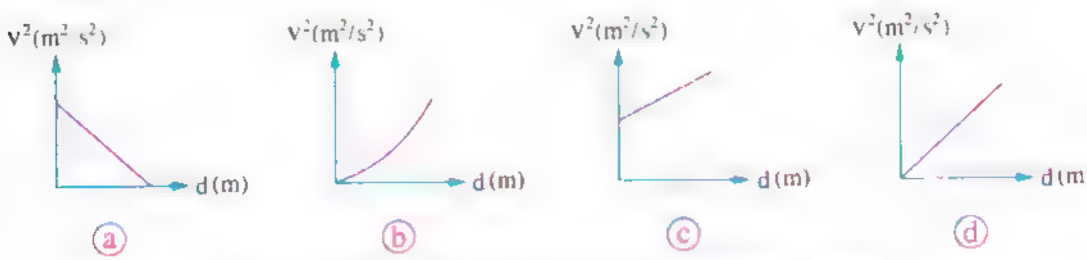
(ii) The height of the object when it reaches a velocity of 20 m/s is ....

ⓐ 320 m ⓑ 200 m ⓒ 160 m ⓓ 80 m

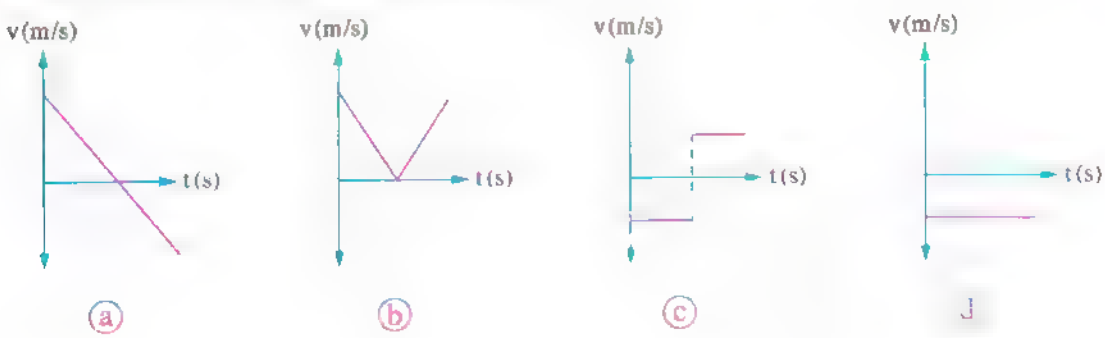
23 ✳ A stone is thrown vertically downwards at velocity of 10 m/s from the edge of a well to reach the bottom after 4 s, then the depth of the well equals .... ($g = 10\ m/s^2$)

ⓐ 80 m ⓑ 120 m ⓒ 160 m ⓓ 240 m

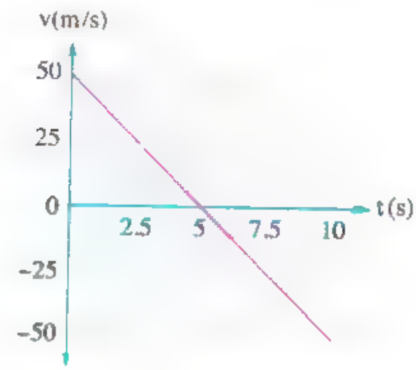
24 The graph that represents the relation between the square of velocity (v^2) and the displacement (d) of an object that is projected vertically upwards at an initial velocity (v_i) till it reaches its maximum height is ....



25 The graph of velocity (v) versus time (t) that represents the motion of an object which is projected vertically upwards and returns back to the point of projection, assuming that the direction of initial velocity is positive, is ....



26 ✳ The opposite graph of velocity versus time represents the motion of a body that is projected vertically upwards, then:



(i) The time taken by the body to reach the maximum height equals ………… .

ⓐ 2.5 s ⓑ 5 s
ⓒ 7.5 s ⓓ 10 s

(ii) The maximum height reached by the body is ………… .

ⓐ 250 m ⓑ 225 m
ⓒ 125 m ⓓ 62.5 m

27 A rock is projected vertically upwards where it reaches the maximum height (d) after time (t), so its average velocity from the moment of projection till it returns to the point of projection equals ………… .

ⓐ zero ⓑ $\frac{d}{t}$ ⓒ $\frac{2d}{t}$ ⓓ $\frac{d}{2t}$

28 ✳ Two balls a and b are projected vertically upwards such that ball a is projected at velocity v and ball b is projected at velocity $\frac{v}{2}$. If the maximum height reached by ball b is h, then the maximum height reached by ball a equals ………… .

ⓐ 2 h ⓑ $\sqrt{2}$ h ⓒ 4 h ⓓ 8 h

29 ✳ Two objects A and B are projected from the top of a building with the same speed, whereas A is projected upwards and B is projected downwards. If the mass of A is greater than the mass of B, then ………… at the moment of reaching the ground (by neglecting the air resistance).

ⓐ $v_A > v_B$ ⓑ $v_A < v_B$ ⓒ $v_A = v_B \neq 0$ ⓓ $v_A = v_B = 0$

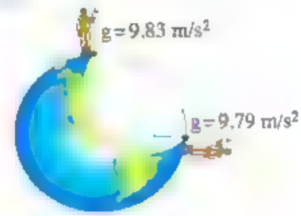
30 An object is projected vertically upwards with a velocity of 15 m/s from a height of 20 m above the Earth's surface, so its velocity when it hits the ground is ………… . ($g = 10$ m/s^2)

ⓐ 20 m/s ⓑ 35 m/s ⓒ 25 m/s ⓓ 15 m/s

Essay questions

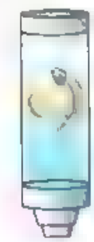
1. If the velocity of a body equals zero at an instant, **is** it necessary that its acceleration at the same instant equals zero? **Give an example.**

2. From the opposite figure:
Explain why the magnitude of the acceleration due to gravity varies from one location to another.

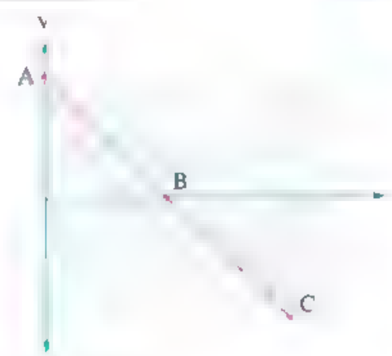


3. **Explain the following sentences:**
(1) When an object falls freely from rest, its velocity increases.
(2) The velocity of a body that is projected vertically upwards decreases till it reaches zero.
(3) At maximum height, the acceleration of the projected object does not equal zero.

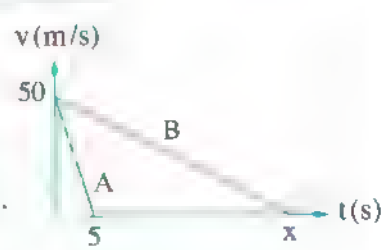
4. In the opposite figure there is a tube which is vacuumed from air, if the tube is inverted **which of the following will be larger** the rate of change of the coin's velocity or the rate of change of the feather's velocity? **And why**?



5. The opposite graph represents the relation between the velocity (v) and the time (t) for an object that moves vertically under the effect of gravity:
Describe the kinematic state (motion) of the object.
What do the points (A) and (C) represent?
What is the relation between them?
(c) **What does** the point (B) represent?



6. The opposite graph represents the relation between the velocity (v) and the time (t) of two objects that were projected vertically upwards; one on the Earth while the other on the Moon. Given that the acceleration due to gravity on the Moon is $\frac{1}{6}$ that on the Earth (g) which equals 10 m/s^2.
(a) **Which** line (A) or (B) represents the projection of the object on the Earth?
Why do the two lines (A) and (B) have different slopes?
(c) **Estimate** the time value at the point (x).
What would happen to the slopes of the two lines when the mass of the object is doubled in both cases? **And why**?



Questions that measure high levels of thinking

Answered in detail

Choose the correct answer:

1 An object falls from the top of a tower to reach the ground 6 s later. If the free fall acceleration is 9.8 m/s^2, then:

(i) The velocity of the object when it reaches the ground is ………… .

ⓐ 117.6 m/s ⓑ 58.8 m/s ⓒ 29.4 m/s ⓓ 14.7 m/s

(ii) The height of the tower equals ………… .

ⓐ 44.1 m ⓑ 89.4 m ⓒ 176.4 m ⓓ 352.8 m

(iii) The distance covered during the last 2 s equals ………… .

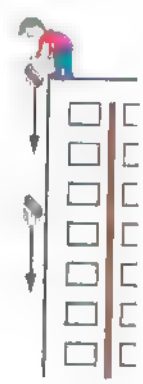
ⓐ 98 m ⓑ 88.2 m ⓒ 58.8 m ⓓ 49 m

2 A stone is let to undergo free fall from rest into a well that contains water at depth of 122.5 m from the edge of the well, hence the sound of the stone hitting the water will be heard after ………… .

(Knowing that: The velocity of the sound in air = 343 m/s, g = 9.8 m/s^2)

ⓐ 4.64 s ⓑ 5 s ⓒ 5.36 s ⓓ 5.72 s

3 A man dropped a stone from the top of a tower of height 100 m and when the stone has covered 10 m, the man dropped another stone as shown in the opposite figure, then the time difference between the two stones arrival to the ground is ………… .
(g = 10 m/s^2)



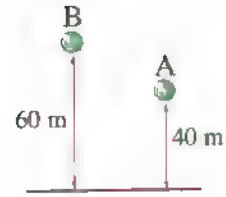
ⓐ $\frac{1}{2}$ s ⓑ $\sqrt{2}$ s

ⓒ 2 s ⓓ $2\sqrt{2}$ s

4 An object falls from the top of a building of height h, then it reaches the middle of the building height after time t, so it covers the other half of the building during time ………… . (g = 10 m/s^2)

ⓐ $\sqrt{2}$ t ⓑ 0.5 t ⓒ 0.33 t ⓓ 0.41 t

5 The opposite figure shows two bodies A, B at different heights, so if body A fell freely towards the ground and at the same instant body B was projected downwards towards the ground with initial velocity v. If the two bodies reach the ground at the same instant, then the value of v is .... $(g = 10\ m/s^2)$



ⓐ $2\sqrt{2}$ m/s
ⓑ $10\sqrt{10}$ m/s
ⓒ $5\sqrt{2}$ m/s
ⓓ $2\sqrt{5}$ m/s

6 A boy projects a ball vertically upwards with velocity v from the top of a building where it rises and then it falls down to hit the ground with velocity 2 v. So, the total distance covered by the ball is .... $(g = 10\ m/s^2)$

ⓐ 30 m
ⓑ 60 m
ⓒ 50 m
ⓓ 120 m

7 Body (A) was projected vertically upwards by initial velocity 20 m/s, then a one second later body (B) was projected vertically upwards from the same point of projection, then the initial velocity that makes body (B) collides with body (A) at the moment when body (A) reaches the maximum height equals .... $(g = 10\ m/s^2)$

ⓐ 10 m/s
ⓑ 15 m/s
ⓒ 25 m/s
ⓓ 30 m/s

Chapter 2

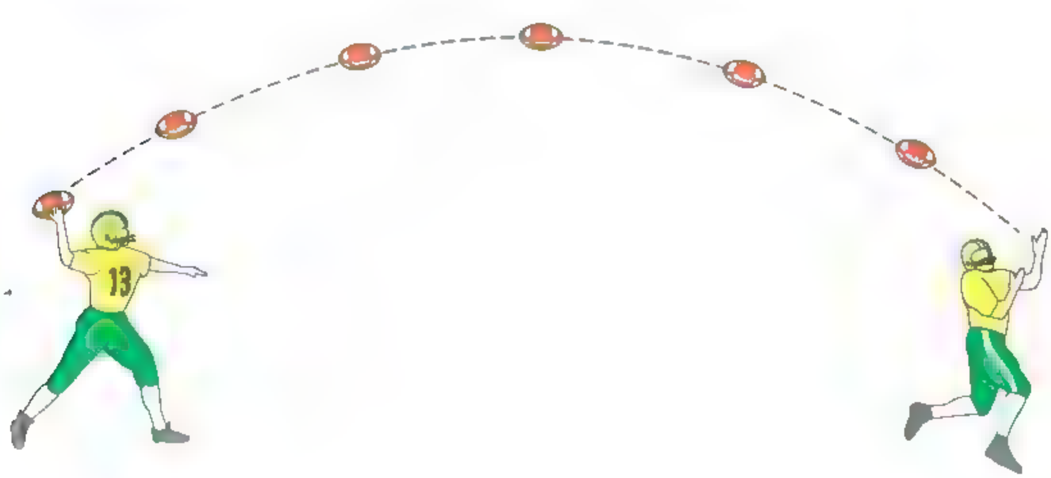
Lesson Three

Follow Applications of Motion with Uniform Acceleration (Two Dimensional Motion)

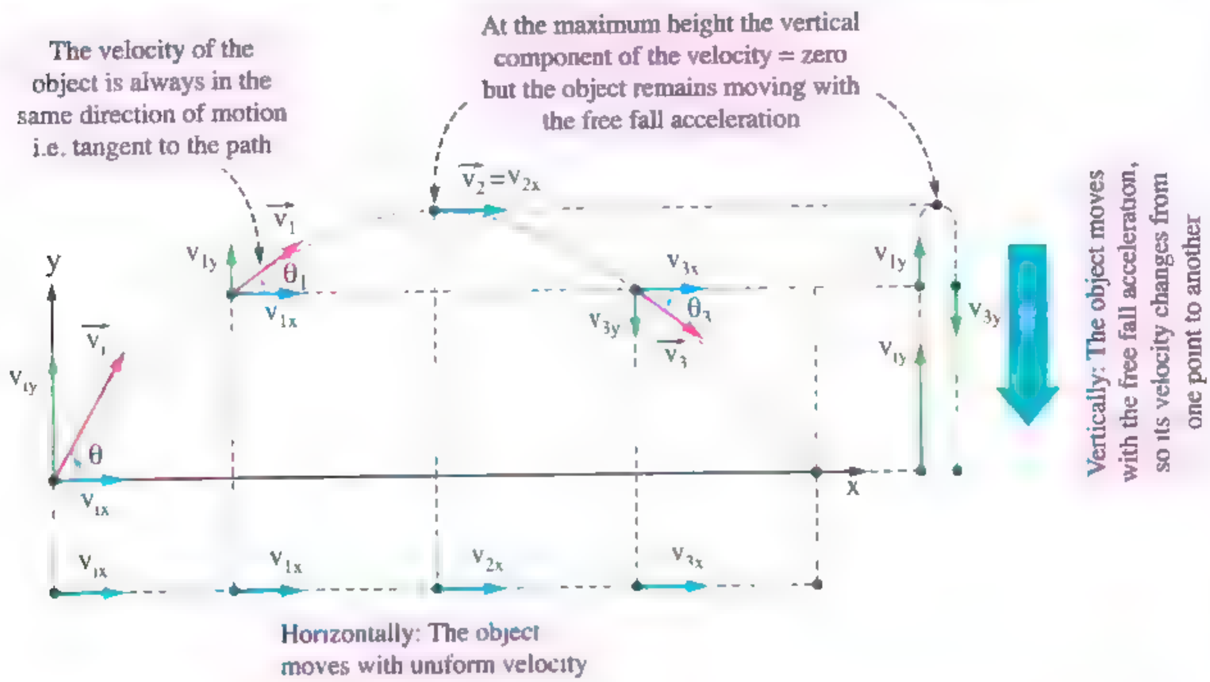
Second Projectiles projected at an angle (Motion in two dimensions)

The motion of the tennis ball and the motion of a runner during the long jump are examples of motion in two dimensions under the effect of gravity only, so they are examples of the free fall motions.

- When a ball is projected upwards with an angle (θ) to the horizontal at an initial velocity (v_i) under only the effect of gravity, the ball follows a curved path (trajectory) as shown in the following figure.



⊙ **We can resolve velocity in two dimensions; horizontal (x) and vertical (y) as follows:**



In the horizontal dimension (x) | In the vertical dimension (y)

The initial velocity

$$v_{ix} = v_i \cos\theta$$

$$v_{iy} = v_i \sin\theta$$

The velocity of the ball at any instant (by using equations of motion)

- The horizontal component of velocity is uniform (assuming that there are no resistive forces).

  ∴ The acceleration in the horizontal direction equals zero ($a_x = 0$)

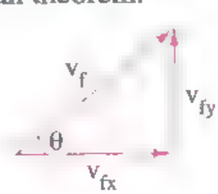
  ∴ $v_{fx} = v_{ix}$

- The vertical component of velocity is variable under the effect of gravity. The acceleration in the vertical direction is the free fall acceleration (g).

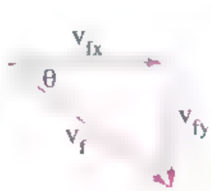
  ∴ v_{fy} can be calculated at any instant from any height by using the equations of motion with uniform acceleration.

The net velocity of the ball at any instant

- By using Pythagorean theorem:



or



$$v_f = \sqrt{v_{fx}^2 + v_{fy}^2}$$

⊙ From the previous, we can conclude that:

When projecting a body at an angle θ with the horizontal, the gravitational force acts to change the vertical component of the velocity but it doesn't affect the horizontal component of the velocity which doesn't change throughout the motion of the body.

Deducing the time (t) of reaching the maximum height and the flight time (T)

$\because v_{fy} = v_{iy} + gt$

When the body reaches the maximum height, the velocity component in the vertical direction (y) vanishes. So, we substitute with ($v_{fy} = 0$) in the first equation of motion:

$\therefore 0 = v_{iy} + gt$

$$\therefore \quad t = \frac{-v_{iy}}{g}$$

The flight time (T): The time taken by the body from its initial point of motion till returning back to the plane of projection which is double the time (t) of reaching the maximum height:

$$\therefore \quad T = 2\,t = \frac{-2\,v_{iy}}{g}$$

Deducing the maximum height reached by the projectile (h)

When the body reaches the maximum height, the velocity component in the vertical direction (y) vanishes ($v_{fy} = 0$), but it has a velocity in the horizontal direction (v_{fx}).

From the third equation of motion:

$\because 2\,ad = v_{fy}^2 - v_{iy}^2 \quad , \quad \therefore 2\,gh = 0 - v_{iy}^2 = -v_{iy}^2$

$$\therefore \quad h = \frac{-v_{iy}^2}{2\,g}$$

Deducing the horizontal range (the maximum horizontal distance reached by the projectile) (R)

$\because$ Time of the maximum horizontal range = Flight time (T)

Substituting by ($a_x = 0$) and ($d = R$) in the second equation of motion:

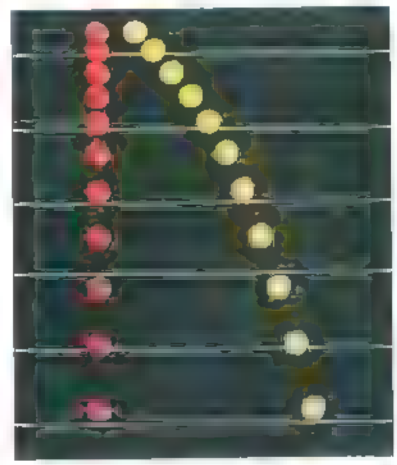
$$\therefore \quad R = v_{ix}\,T = 2\,v_{ix}\,t = \frac{-2\,v_{ix}\,v_{iy}}{g} = \frac{-2\,v_i^2 \cos\theta \sin\theta}{g} = \frac{-v_i^2 \sin 2\theta}{g}$$

Integration with Mathematics

You can revise the trigonometrical relations from section (4) page (10).

Note:

- If a ball is dropped to fall freely and another ball is projected horizontally ($v_{iy} = 0$) at the same moment as shown in the opposite figure, we will notice that the two balls have the same vertical displacement throughout their motions which means that their vertical motions are identical, so the vertical motion for the two balls is free fall motion and therefore the motion of the projected body at an angle can be resolved into a motion in the vertical direction and a motion in the horizontal direction noticing that the two motions are not depending on each other.



Example 1

A motorcycle rushed at 15 m/s in a direction that makes an angle of 30° to the horizontal, then: *($g = 10\ m/s^2$)*

(i) The maximum height reached by the motorcycle above the level of projection is ....

ⓐ 1.6 m ⓑ 2.8 m ⓒ 4.5 m ⓓ 5.2 m

(ii) The time taken by the motorcycle to return to the same level of its projection is ....

ⓐ 3 s ⓑ 2.5 s ⓒ 1.5 s ⓓ 0.5 s

(iii) The horizontal distance covered by the motorcycle when it returns to the same horizontal level from which it was projected is ....

ⓐ 30.35 m ⓑ 25.7 m ⓒ 22.8 m ⓓ 19.5 m

Solution

$v_i = 15$ m/s $\theta = 30°$ $g = 10\ m/s^2$ $h = ?$ $T = ?$ $R = ?$

$v_{ix} = v_i \cos\theta = 15 \times \cos 30 = 13$ m/s

$v_{iy} = v_i \sin\theta = 15 \times \sin 30 = 7.5$ m/s

(i) $h = \frac{-v_{iy}^2}{2g} = \frac{-(7.5)^2}{2 \times (-10)} = 2.8$ m

$\therefore$ **The correct choice is ⓑ.**

(ii) $T = 2t = \frac{-2v_{iy}}{g} = \frac{-2 \times 7.5}{-10} = 1.5\ s$

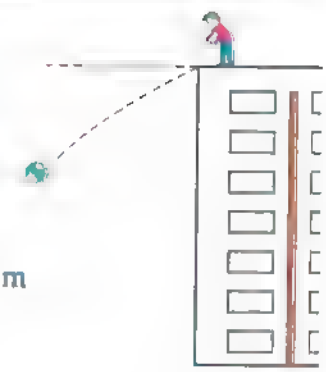
$\therefore$ **The correct choice is ⓒ.**

(iii) $R = v_{ix}\, T = 13 \times 1.5 = 19.5\ m$

$\therefore$ **The correct choice is ⓓ.**

Example 2

In the opposite figure, a man who stands on the top of a building, projects a ball with an initial velocity 10 m/s in a direction that makes an angle of 30° with the horizontal. If the ball spent 4 s to reach the ground then: $(g = 10\ m/s^2)$



(i) The height of the building is ....

ⓐ 100 m　ⓑ 180 m　ⓒ 210 m　ⓓ 225 m

(ii) When the ball reaches the ground, the horizontal distance between the ball and the base of the building is ....

ⓐ 25.12 m　ⓑ $20\sqrt{3}$ m　ⓒ 50.25 m　ⓓ $40\sqrt{3}$ m

Solution

$v_i = 10\ m/s$　$\theta = 30°$　$t = 4\ s$　$g = 10\ m/s^2$　$h = ?$　$d = ?$

Clue

* *The relations that are deduced for the flight time (T), the maximum vertical height (h) and the maximum horizontal range (R) are applied in the case of projecting a body from a certain point where it returns to another point in the same horizontal level.*
* *If the path of the projectile is different from the previous case, we don't use these relations, but we use:*

(1) The equations of motion with uniform acceleration to calculate the time of motion and the vertical displacement.

(2) The equation of motion with uniform velocity to calculate the horizontal range of the projectile.

(i) $v_{iy} = v_i \sin\theta = 10 \sin 30° = 5\ m/s$

$h = v_{iy}t + \frac{1}{2}gt^2 = (5 \times 4) + \left(\frac{1}{2} \times 10 \times (4)^2\right) = 100\ m$

$\therefore$ **The correct choice is ⓐ.**

(ii) $v_{ix} = v_i \cos\theta = 10 \times \cos 30° = 5\sqrt{3}$ m/s

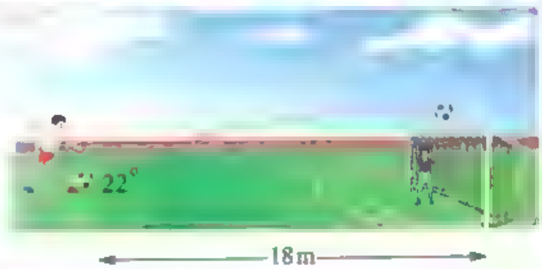
$d = v_{ix} t = 5\sqrt{3} \times 4 = 20\sqrt{3}$ m

$\therefore$ **The correct choice is ⓑ.**

What if the same person projects another ball horizontally to reach the ground at the same point, **what** is the velocity by which the ball is projected?

Example 3

A football player has kicked a ball at an angle of 22° to the horizontal with a velocity of 23 m/s towards the goal that is 18 m away from him, then: ***($g = 9.8$ m/s^2)***



(i) The time taken by the ball to reach the goal is ....

ⓐ 0.84 s ⓑ 2.09 s ⓒ 5.16 s ⓓ 8.94 s

(ii) The vertical height of the ball from the ground when it reaches the goal is ....

ⓐ 3.78 m ⓑ 10.69 m ⓒ 14.46 m ⓓ 21.37 m

Solution

$\theta = 22°$ $v_i = 23$ m/s $d = 18$ m $g = 9.8$ m/s^2 $t = ?$ $h = ?$

(i) $v_{ix} = v_i \cos\theta = 23 \cos 22 = 21.33$ m/s

$$v_{ix} = \frac{d}{t}$$

$$\therefore t = \frac{d}{v_{ix}} = \frac{18}{21.33} = 0.84 \text{ s}$$

$\therefore$ **The correct choice is ⓐ.**

(ii) $v_{iy} = v_i \sin\theta = 23 \sin 22 = 8.62$ m/s

From the second equation of motion:

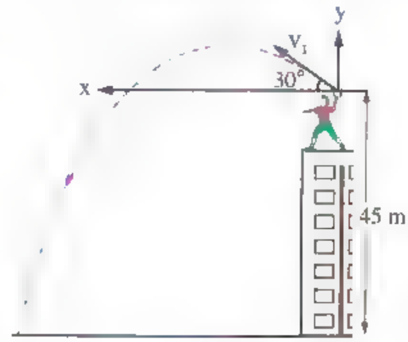
$$h = v_{iy} t - \frac{1}{2} g t^2$$

$$= (8.62 \times 0.84) - \left(\frac{1}{2} \times 9.8 \times (0.84)^2\right) = 3.78 \text{ m}$$

$\therefore$ **The correct choice is ⓐ.**

Example 4

The opposite figure shows a man projecting a stone upward at an angle of 30° to the horizontal with initial velocity of 20 m/s, then: $(g = 9.8\ m/s^2)$



(i) The time taken by the stone to reach the ground is ....

ⓐ 3.12 s ⓑ 4.22 s
ⓒ 5.35 s ⓓ 8.64 s

(ii) The velocity of the stone at the moment of reaching the ground is ....

ⓐ 19.3 m/s ⓑ 28.2 m/s ⓒ 30.56 m/s ⓓ 35.8 m/s

Solution

$\theta = 30°$	$v_i = 20$ m/s	$d = 45$ m	$g = 9.8\ m/s^2$	$t = ?$	$v_f = ?$

Assume that the positive direction of motion is upwards.

(i) $v_{iy} = v_i \sin\theta = 20 \sin 30 = 10$ m/s

$$d = v_{iy}\, t - \frac{1}{2} g t^2$$

$$-45 = 10\, t - \left(\frac{1}{2} \times 9.8\, t^2\right)$$

$$4.9\, t^2 - 10\, t - 45 = 0$$

Solve the equation by using the calculator: $t = 4.22$ s

∴ **The correct choice is ⓑ.**

Integration with Mathematics

You can revise how to solve second degree equation with one unknown from section (9) page (15).

(ii) $v_{ix} = v_{fx} = v_i \cos\theta = 20 \cos 30 = 10\sqrt{3}$ m/s

From the first equation of motion:

$$v_{fy} = v_{iy} - g\, t = 10 - (9.8 \times 4.22) = -31.36 \text{ m/s}$$

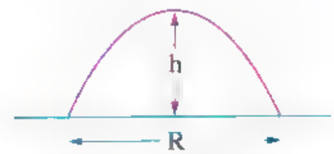
$$v_f = \sqrt{v_{fx}^2 + v_{fy}^2} = \sqrt{(10\sqrt{3})^2 + (-31.36)^2} = 35.8 \text{ m/s}$$

∴ **The correct choice is ⓓ.**

What if another stone was projected at the same angle to the horizontal but downwards with the same initial velocity, **what** will be the time taken by the stone to reach the ground?

Example 5

The opposite figure represents the trajectory of a body that is projected upwards at an angle θ. If the horizontal range of the body is double the maximum vertical height reached by the body, then θ equals ....



ⓐ 26.56° ⓑ 30° ⓒ 45° ⓓ 63.4°

Solution

$R = 2h$ $\theta = ?$

$\because R = v_{ix} T = \frac{-2 v_{ix} v_{iy}}{g}$ $\because h = \frac{-v_{iy}^2}{2g}$ $\because R = 2h$

$\therefore \frac{-2 v_{ix} v_{iy}}{g} = \frac{-2 v_{iy}^2}{2g}$

$2 v_{ix} = v_{iy}$ $2 v_i \cos\theta = v_i \sin\theta$

$\frac{\sin\theta}{\cos\theta} = 2$ $\tan\theta = 2$

$\therefore \theta = 63.4°$

∴ **The correct choice is ⓓ.**

Example 6

A box is dropped from an airplane that flies horizontally with a velocity of 300 km/h at a height of 50 m above the surface of the sea, then: $(g = 9.8 \text{ m/s}^2)$

(i) The time taken by the box to reach the surface of the sea equals ....

ⓐ 0.16 s ⓑ 3.2 s ⓒ 8.4 s ⓓ 10.2 s

(ii) The horizontal distance covered by the box from the moment of its falling till it reaches the surface of the sea surface is ....

ⓐ 98.2 m ⓑ 126.1 m ⓒ 266.6 m ⓓ 849.7 m

Solution

$v_{airplane} = 300$ km/h $h = 50$ m $g = 9.8 \text{ m/s}^2$ $t = ?$ $d = ?$

Clue

The box acquires the velocity of the airplane and therefore its initial velocity is equal to the velocity of the airplane. Since, the airplane is moving horizontally:

$$\therefore v_{airplane} = (v_i)_{box} = (v_{ix})_{box} \quad , \quad (v_{iy})_{box} = 0$$

Assume that the positive direction of motion is downwards.

(i) From the second equation of motion:

$h = (v_{iy})_{box}\, t + \frac{1}{2} g t^2$ $\qquad 50 = 0 + \left(\frac{1}{2} \times 9.8\, t^2\right)$

$t = 3.2$ s

$\therefore$ **The correct choice is (b).**

(ii) $(v_{ix})_{box} = 300 \times \frac{1000}{60 \times 60} = 83.3$ m/s $\qquad (v_{ix})_{box} = \frac{d}{t}$

$d = (v_{ix})_{box}\, t = 83.3 \times 3.2 = 266.6$ m

$\therefore$ **The correct choice is (c).**

What if the airplane flies with a velocity greater than the velocity in the previous case, **will** the box take less time to reach the surface of the sea?

Do you know ...?

1. The projectile reaches maximum horizontal range for the given initial speed when it is projected at an angle 45°, where:

$R = v_{ix}\, T = 2\, v_{ix}\, t$

$= \frac{-2\, v_{ix}\, v_{iy}}{g}$

$= \frac{-2\, v_i^2 \sin\theta \cos\theta}{g}$

$\because 2 \sin\theta \cos\theta = \sin 2\theta$

$\because R = \frac{-v_i^2}{g} \sin 2\theta$ $\qquad$ When: $\theta = 45°$, Then, $\sin 2\theta = \sin 90 = 1$

$\therefore$ R is maximum (maximum horizontal range)

2. The horizontal range will be the same for projectiles that are projected at two different angles (θ_1, θ_2) with the same initial speed when the sum of the two angles is 90° $(\theta_1 + \theta_2 = 90°)$ and that is because $\sin 2\theta_1 = \sin 2\theta_2$. So, when a body is projected at an angle of 75° with a certain initial speed, it reaches a maximum height h_1 and also a horizontal range R_1 and when another body is projected with the same initial speed at an angle of 15°, it reaches a maximum height h_2 and a horizontal range R_2 such that $(h_1 > h_2)$ and $(R_1 = R_2)$.

Test yourself

Answered

1 Choose the correct answer :

(1) A body is projected at an angle θ with the horizontal, so at which point do the direction of the body's velocity and the direction of the body's acceleration due to gravity become:

(i) perpendicular?

(a) At the moment of projection.
(b) At the maximum height reached by the body.
(c) When the body returns to the same level of projection.
(d) They won't be perpendicular at any point during the motion.

(ii) parallel?

(a) At the moment of projection.
(b) At the maximum height reached by the body.
(c) When the body returns to the same level of projection.
(d) They won't be parallel at any point during the motion.

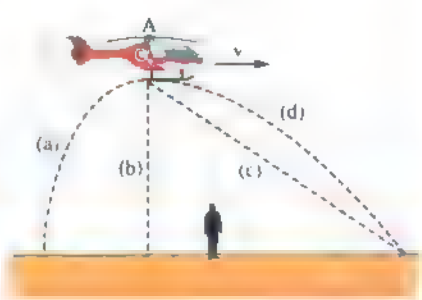
(2) A ball of mass 100 g rolls on a horizontal smooth table with a certain velocity till it reaches the edge of the table where it falls 2 m away from the base of the table. If another ball of mass 200 g rolls on the table with the same velocity, then the distance between the point at which it falls and the base of the table will be ....

(a) 1 m (b) greater than 1 m and less than 2 m
(c) 2 m (d) greater than 2 m

(3) Five identical bodies are projected with the same speed at different angles to the horizontal. If the horizontal range of the body that is projected at angle 20° is R, then the body that has a horizontal range less than R is the body that is projected at angle ....

(a) 40° (b) 50° (c) 70° (d) 80°

(4) The opposite figure shows a helicopter flying horizontally with uniform velocity. If a first aid kit is dropped from the helicopter when it is at point A, then the path of the kit during falling will be the path ....



(a) a (b) b
(c) c (d) d

2 If the magnitude of the initial velocity of launching a projectile equals 5 times its magnitude at its maximum height, **calculate** the angle of its projection.

....

....

Chapter 2

Questions on Lesson Three

Follow Applications of Motion with Uniform Acceleration (Two Dimensional Motion)

To watch videos of how to solve questions use the App

GPS

Interactive test

The questions signed by ✳ are answered in detail

Test — Multiple choice questions

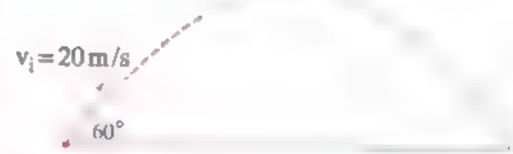
1 When the projectile which is projected upward at an angle returns to the same horizontal level of projection after time T, so it has reached the maximum height after time ....

(a) $\frac{1}{2}$ T (b) T (c) 2 T (d) T^2

2 The horizontal displacement reached by two identical projectiles will be the same when they are projected at the same initial velocity from the same point at angles ....

80° and 60° 40° and 50° 80° and 20° 80° and 30°

3 ✳ A body is projected with a velocity of 20 m/s upward at an angle of 60° to the horizontal as shown in the opposite figure, then: ($g = 10\ m/s^2$)



(i) The horizontal component of the body's velocity at the moment of projection is ....

(a) 10 m/s (b) $10\sqrt{3}$ m/s (c) $\frac{40}{\sqrt{3}}$ m/s (d) 40 m/s

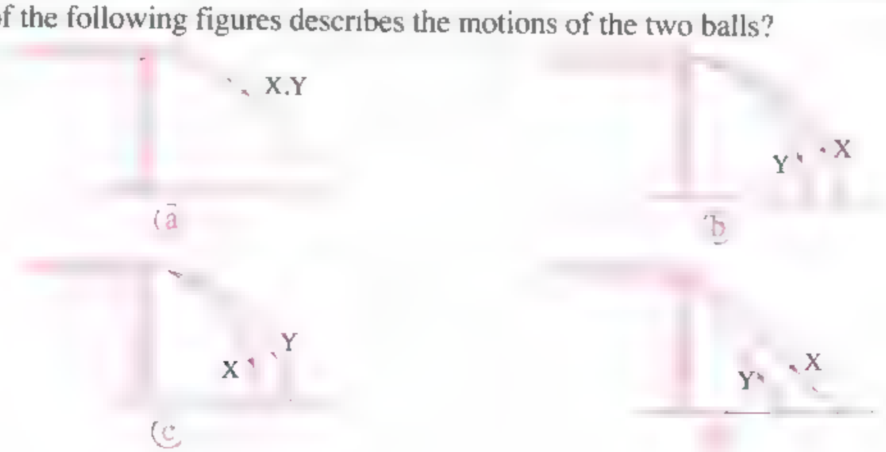
(ii) The vertical component of the body's velocity at the moment of projection is ....

(a) 10 m/s (b) $10\sqrt{3}$ m/s (c) $\frac{40}{\sqrt{3}}$ m/s (d) 40 m/s

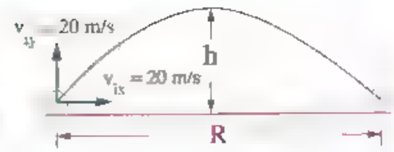
(iii) The vertical component of the body's velocity after one second from the moment of projection is ....

(a) 27.32 m/s (b) 20 m/s (c) 13.1 m/s (d) 7.32 m/s

4 Two balls X and Y roll from the top of a table with the same horizontal velocity, where the mass of X is greater than the mass of Y. If we neglect the effect of air resistance, which of the following figures describes the motions of the two balls?



5 The opposite figure shows an object that is projected at an angle, if: $(g = 10\ m/s^2)$



(i) The maximum vertical height reached by the object is given by the relation; $h = \frac{-(v_{iy})^2}{2g}$, then the value of h is ....

ⓐ 400 m ⓑ 100 m ⓒ 20 m ⓓ 10 m

(ii) The maximum horizontal range reached by the object is given by the relation; $R = \frac{-2 v_{ix} v_{iy}}{g}$, then the value of R is ....

ⓐ 800 m ⓑ 80 m ⓒ 200 m ⓓ 20 m

6 ✻ If an object is projected upwards at an angle of 30° to the horizontal and with an initial velocity of 20 m/s, the maximum height reached by the object will be .... (Consider: $g = 10\ m/s^2$)

ⓐ 5 m ⓑ 10 m ⓒ 15 m ⓓ 20 m

7 ✻ A ball is projected from the ground with a velocity of 20 m/s at an angle of 60° to the horizontal, then: $(g = 10\ m/s^2)$

(i) The maximum height reached by the ball is ....

ⓐ 0.866 m ⓑ 5 m ⓒ 15 m ⓓ 30 m

(ii) The maximum horizontal range reached by the ball when it returns to the ground is ....

ⓐ 34.64 m ⓑ 38.5 m ⓒ 41.3 m ⓓ 60 m

8 ✻ An object is projected at an angle of 30° to the horizontal and returns to the Earth's surface after 4 s, then: $(g = 10\ m/s^2)$

(i) The initial velocity by which the object is projected equals ....

ⓐ 60 m/s ⓑ 40 m/s ⓒ 35 m/s ⓓ 20 m/s

(ii) The horizontal component of the object velocity at the moment of projection is ....

ⓐ $30\sqrt{3}$ m/s ⓑ $20\sqrt{3}$ m/s ⓒ $10\sqrt{3}$ m/s ⓓ $5\sqrt{3}$ m/s

(iii) The maximum height reached by the object is ....

ⓐ 45 m ⓑ 20 m ⓒ 5 m ⓓ 1.25 m

9 ✻ A cannon that is placed on the ground fires projectiles at an angle of 45° to the horizontal, so the initial velocity that is required for firing the projectiles to hit a target 1000 m away from the cannon is .... $(g = 10\ m/s^2)$

ⓐ 150 m/s ⓑ 100 m/s ⓒ 75 m/s ⓓ 50 m/s

10 ✳ A person throws a ball from the top of a building with a speed of 50 m/s, so the velocity of the ball and its vertical displacement after 4 s in the case of: $(g = 10\ m/s^2)$

(i) projecting the ball upward an angle of 60° to the horizontal are ....

	Velocity	Vertical displacement
ⓐ	28.3 m/s	253.2 m
ⓑ	28.3 m/s	93.2 m
ⓒ	25.22 m/s	253.2 m
ⓓ	25.22 m/s	93.2 m

(ii) projecting the ball horizontally are ....

	Velocity	Vertical displacement
ⓐ	90 m/s	80 m
ⓑ	90 m/s	160 m
ⓒ	64.03 m/s	80 m
ⓓ	64.03 m/s	160 m

11 ✳ An officer adjusts a cannon that is placed on the ground in a training task. If the cannon fires a projectile: $(g = 10\ m/s^2)$

(i) at an angle of 60° to the horizontal to reach a maximum height of 2000 m, the initial speed of projectile equals ....

ⓐ 163.3 m/s ⓑ 200 m/s ⓒ 230.94 m/s ⓓ 400 m/s

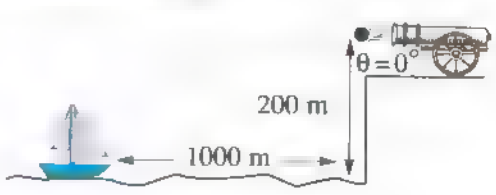
(ii) with a velocity of 800 m/s at an angle of 10° to the vertical, the projectile speed after 10 s from the moment of projection equals ....

ⓐ 548.93 m/s ⓑ 673.68 m/s ⓒ 701.74 m/s ⓓ 826.77 m/s

(iii) at an angle θ to reach the maximum horizontal range for a given initial speed, the angle θ equals ....

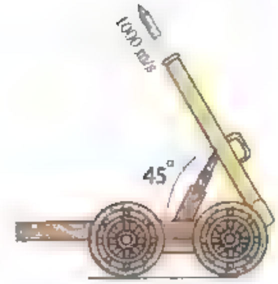
ⓐ 0° ⓑ 30° ⓒ 45° ⓓ 60°

12 ✳ The opposite figure shows the trajectory of a cannonball that is projected horizontally from a height of 200 m above sealevel to hit a ship at a horizontal distance of 1000 m from the cannon, so the projection velocity of the cannonball approximately equals .... $(g = 10\ m/s^2)$



ⓐ 100 m/s ⓑ 158 m/s ⓒ 171 m/s ⓓ 227 m/s

13 * The opposite figure shows the launching of a projectile from a cannon, then: $(g = 10\ m/s^2)$



(i) The vertical component of the projectile's velocity equals zero after ………

ⓐ 70.71 s ⓑ 141.42 s
ⓒ 282.8 s ⓓ 402.1 s

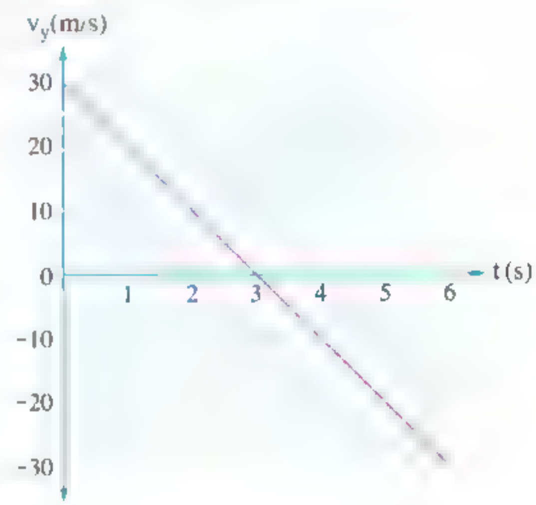
(ii) The required time for this projectile to hit a target that is at the same horizontal level of the cannon is ………

ⓐ 70.71 s ⓑ 141.42 s ⓒ 150.3 s ⓓ 166.2 s

(iii) The maximum horizontal range for this cannon when the projectile returns to the same horizontal level from which it was projected is approximately equal to ………

ⓐ 100 m ⓑ 50 km ⓒ 100 km ⓓ 200 km

14 * The opposite graph represents the change of the vertical component of the velocity of a body that is projected in the gravitational field of Earth with time. If the angle of projection was 30° to the horizontal, then: $(g = 10\ m/s^2)$



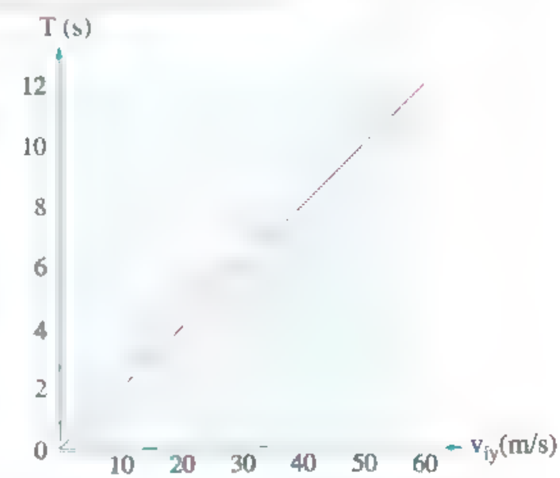
(i) The maximum height reached by the body equals ………

ⓐ 180 m ⓑ 90 m
ⓒ 45 m ⓓ 30 m

(ii) The horizontal range of the body equals ………

ⓐ 90 m ⓑ 180 m ⓒ 155.9 m ⓓ 311.76 m

15 * A body is projected from the ground at an angle of 45° to the horizontal several times with different initial velocities whereas the time interval (T) taken by the body for returning back to the ground is measured and plotted versus the vertical component of the initial velocity (v_{iy}) by which the body is projected in the opposite graph, then:



(i) The horizontal component of the body's velocity at T = 6 s equals ………

ⓐ 10 m/s ⓑ 15 m/s ⓒ 30 m/s ⓓ 60 m/s

(ii) The horizontal range reached by the body at T = 10 s equals ....

ⓐ 125 m ⓑ 250 m ⓒ 500 m ⓓ 1000 m

16 ✻ An object is projected at an initial speed v_i in a direction making an angle of 60° to the horizontal to reach a horizontal range R. If the object is projected with the same initial speed, it reaches a greater range when it is projected at an angle of ....

ⓐ 90° ⓑ 75° ⓒ 44° ⓓ 30°

17 ✻ A projectile was launched upward once with velocity v and another time from the same point with velocity $\frac{v}{2}$ and at the same angle of projection to return back to the same level in both cases, so the ratio between the horizontal range of the projectile in the first case and the horizontal range of it in the second case $(\frac{R_1}{R_2})$ equals ....

ⓐ $\frac{4}{1}$ ⓑ $\frac{2}{1}$ ⓒ $\frac{1}{2}$ ⓓ $\frac{1}{4}$

18 Two projectiles A and B are projected with the same speed from the ground, where θ is the angle at which projectile A is launched to the horizontal and also it is the angle at which projectile B is launched to the vertical given that θ < 45°, then the two projectiles return back to the ground after having the same ....

ⓐ flight time ⓑ maximum height

ⓒ horizontal range ⓓ vertical initial velocity

19 ✻ A body is projected at an angle θ to the horizontal with an initial velocity v_i, if $v_{ix} = v_{iy} = 20$ m/s, then v_i and θ values are .... and .... respectively.

ⓐ 40 m/s, 60° ⓑ $20\sqrt{2}$ m/s, 45° ⓒ 40 m/s, 45° ⓓ $20\sqrt{2}$ m/s, 30°

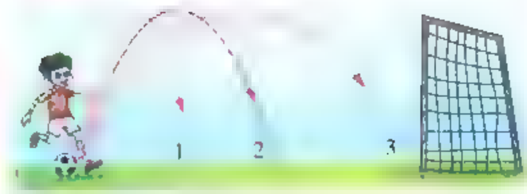
20 ✻ A body is projected at an angle of 30° to the horizontal at an initial velocity v_i, after 4 s its velocity in the vertical dimension during ascending becomes $\frac{1}{4}$ v_i, so the value of v_i is .... ($g = 10$ m/s^2)

ⓐ 7.5 m/s ⓑ 40 m/s ⓒ 80 m/s ⓓ 160 m/s

21 ✻ A body is projected upward at an angle θ to the horizontal with an initial velocity v_i, if $v_{iy} = 2\, v_{ix}$, then the value of θ is ....

ⓐ 30° ⓑ 60° ⓒ 63.43° ⓓ 36.51°

22 ✳ The opposite figure shows three paths of a football that is projected from the ground to reach the same vertical height. By neglecting the air resistance, the correct arrangement of the three paths according to:



(i) The vertical component of the initial velocity is ....

ⓐ $1 > 2 > 3$ ⓑ $1 < 2 < 3$ ⓒ $2 > 1 = 3$ ⓓ $1 = 2 = 3$

(ii) The flight time is ....

ⓐ $1 > 2 > 3$ ⓑ $2 > 1 = 3$ ⓒ $3 > 2 > 1$ ⓓ $1 = 2 = 3$

(iii) The horizontal component of the initial velocity is ....

ⓐ $1 > 2 > 3$ ⓑ $1 < 2 < 3$ ⓒ $1 < 3 < 2$ ⓓ $1 = 2 = 3$

(iv) The initial velocity is ....

ⓐ $1 > 2 > 3$ ⓑ $1 < 2 < 3$ ⓒ $1 > 3 > 2$ ⓓ $1 = 2 = 3$

23 ✳ A bomb is dropped from a plane that is flying horizontally with velocity 100 m/s at a height of 4 km above the level of a target on the ground to hit that target, then: ($g = 10\ m/s^2$)

(i) The time taken by the bomb to reach the target equals ....

ⓐ $15\sqrt{3}$ s ⓑ $18\sqrt{3}$ s ⓒ $20\sqrt{2}$ s ⓓ $25\sqrt{2}$ s

(ii) The horizontal distance between the position of dropping the bomb and the target equals ....

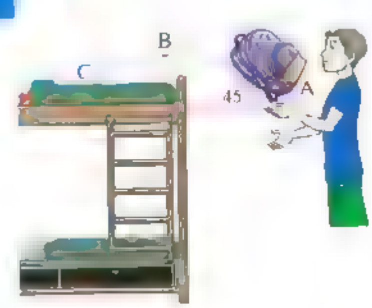
ⓐ 1765.4 m ⓑ 2205 m ⓒ 2828.4 m ⓓ 3126.2 m

(iii) The final speed of the bomb at the moment of hitting the target equals ....

ⓐ 150 m/s ⓑ 300 m/s ⓒ 400 m/s ⓓ 1000 m/s

Essay questions

1 A student has thrown his school bag on his bed at an angle of 45° to the horizontal as in the opposite figure where it passes by point A after leaving the student's hand directly then it passes by point B at its maximum height to reach point C before it touches the bed, **arrange:**

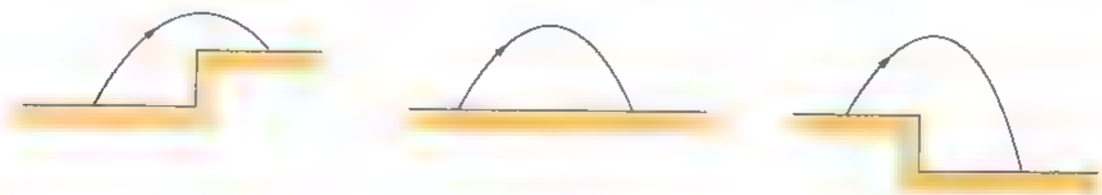


(a) The horizontal components of the bag velocity at the points A, B and C.

(b) The vertical components of the bag velocity at the points A, B and C.

(c) The magnitude of the bag acceleration at the points A, B and C.

2 The next figures show three identical projectiles which are projected from the same level with the same velocity at the same angle, but they aren't landing at the same horizontal level. **Arrange the three cases according to the final velocity of each projectile before landing. Explain your answer.**



(1) **(2)** **(3)**

Questions that measure high levels of thinking

Answered in detail

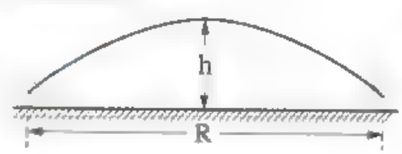
Choose the correct answer:

1 Three identical balls are projected at the same moment from the same point with the same speed, where the first ball is projected vertically upwards, the second ball is projected upward at an angle of 45° to the horizontal and the third ball is projected upward at an angle of 60° to the horizontal. So, the ball that hits the ground first is ......

(a) the first ball (b) the second ball

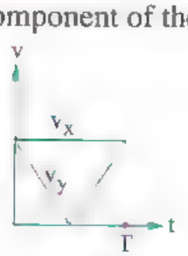
(c) the third ball (d) all the balls reach the ground at the same moment

2 The opposite figure shows the trajectory of a projectile. If $h = \frac{R}{4}$, then the projectile was projected at an angle of .... to the horizontal.

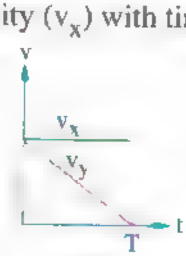


(a) 30° (b) 45° (c) 60° (d) 75°

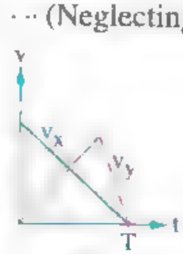
3 A projectile was launched from the ground at angle of 45° to the horizontal, then returned back to the ground after time T, so the graph that represents the change in the magnitude of the vertical component of the velocity (v_y) and the magnitude of the horizontal component of the velocity (v_x) with time is ...... (Neglecting air resistance)



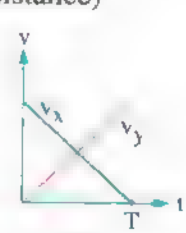
(a)



(b)

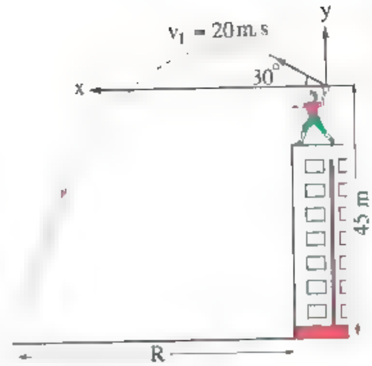


(c)



(d)

4 The opposite figure shows a man projecting a ball from the top of a building at an angle of 30° to the horizontal, then: ($g = 10\ m/s^2$)



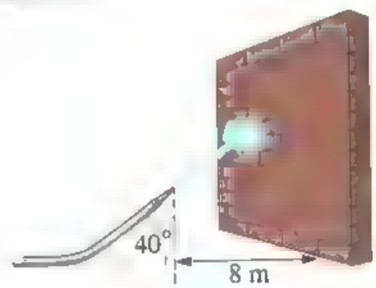
(i) The time taken by the ball to reach the ground equals ·········

ⓐ 2.41 s   ⓑ 4.16 s
ⓒ 5.22 s   ⓓ 6.31 s

(ii) The magnitude of the horizontal displacement covered by the ball (R) equals ·········

ⓐ 30.2 m   ⓑ 40.15 m   ⓒ 60.03 m   ⓓ 72.05 m

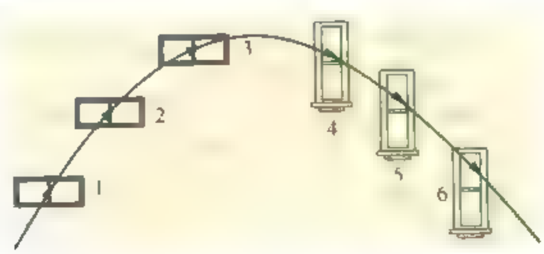
5 In the opposite figure, a hose sprays a water current upward at an angle of 40° to the horizontal with a velocity of 20 m/s, so at what height from the hose nozzle the water will hit a wall that is at a horizontal distance 8 m away from the hose nozzle? ($g = 9.8\ m/s^2$)



ⓐ 4.14 m   ⓑ 5.36 m
ⓒ 8.01 m   ⓓ 9.23 m

Answer the following questions :

6 The next figure shows the trajectory of a ball that is projected to pass by three identical windows 1, 2 and 3 while elevating and another three identical windows 4, 5 and 6 while descending. **Arrange the windows (1, 2 and 3) and also the windows (4, 5 and 6)** according to the average speed of the ball while passing by each window.



Test on Chapter 2

Motion with Uniform Acceleration

First — Choose the correct answer

1 A body that is projected vertically upwards from the ground reaches the maximum height and returns back to the point of projection after 10 s. If air resistance is neglected, then the ratio between the speed of the body at the instant of projection and the speed of the body at the instant of returning to the point of projection is .... $(g = 10\ m/s^2)$

ⓐ larger than one ⓑ less than one ⓒ equal to one ⓓ no correct answer

2 If a body starts its motion from rest with a uniform acceleration to reach a velocity 6 m/s after the third second, so its average velocity through 100 m from the start of its motion equals ....

ⓐ 6 m/s ⓑ 50 m/s ⓒ 10 m/s ⓓ 100 m/s

3 If the maximum height reached by a projectile that is launched from a horizontal level and returns back to it is 40 m and the maximum horizontal range reached by it is $160\sqrt{3}$ m, then the angle at which the projectile is launched equals ....

ⓐ 15° ⓑ 30° ⓒ 45° ⓓ 60°

4 A body starts its motion from rest with a uniform acceleration of $2\ m/s^2$ to cover a distance of 100 m during ....

ⓐ 2.5 s ⓑ 5 s ⓒ 10 s ⓓ 20 s

5 A projectile that is launched upward with an initial velocity of v_i at an angle of 30° to the horizontal reaches its maximum height after 4 s, then the value of v_i is ....
$(g = 10\ m/s^2)$

ⓐ 20 m/s ⓑ 40 m/s ⓒ 80 m/s ⓓ 100 m/s

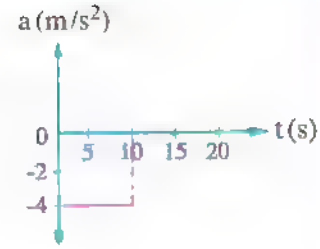
6 A body that falls from the top of a building reaches a velocity of 20 m/s at the middle of the building height, so the height of the building equals .... $(g = 10\ m/s^2)$

ⓐ 10 m ⓑ 20 m ⓒ 30 m ⓓ 40 m

7 A body is projected with an initial velocity of 30 m/s at an angle of 30° to the vertical, so its horizontal velocity equals ....

ⓐ 15 m/s ⓑ $15\sqrt{3}$ m/s ⓒ $20\sqrt{2}$ m/s ⓓ $10\sqrt{10}$ m/s

8. The opposite graph of acceleration (a) versus time (t) represents the motion of an airplane that flies in a straight line. If the velocity of the plane at t = 0 is 60 m/s, then its velocity after 10 s is ....



(a) 40 m/s (b) 30 m/s
(c) 20 m/s (d) 10 m/s

9. When a body is projected vertically upwards, then during its rising ....

(a) the direction of its velocity and acceleration is upwards.
(b) the direction of its velocity is upwards and the direction of its acceleration is downwards.
(c) the direction of its velocity and acceleration is downwards.
(d) the direction of its velocity is downwards and the direction of its acceleration is upwards.

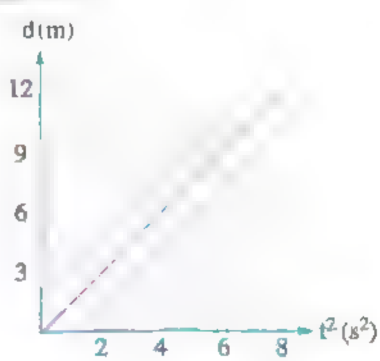
10. A ball is projected with initial speed v_i at angle 15° to the horizontal, hence its horizontal range is R, then it will reach the same horizontal range when it is projected with the same speed at an angle of ....
(Knowing that: The ball returns to the same horizontal level from which it was projected in the two cases)

(a) 115° (b) 30° (c) 60° (d) 75°

11. A stone is dropped from the top of a 100 m high building to fall from rest, so it passes by the start of a balcony after 4 s from the instant of dropping. Then the height of the start of this balcony from the ground surface equals .... $(g = 10\ m/s^2)$

(a) 80 m (b) 60 m (c) 40 m (d) 20 m

12. The opposite graph of displacement (d) versus time squared (t^2) represents the motion of a car starting from rest on a straight road. Then, the magnitude of the acceleration of the car equals ....

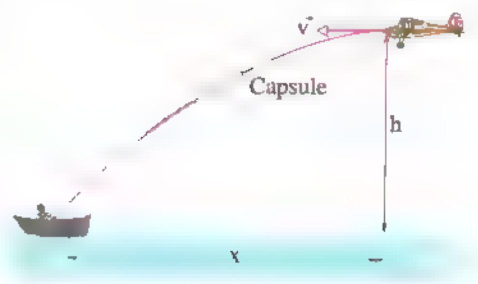


(a) 1 m/s^2 (b) 1.5 m/s^2
(c) 2 m/s^2 (d) 3 m/s^2

13. A body starts its motion from rest in a straight line with a uniform acceleration of 2 m/s^2 to cover a distance of 100 m, then it moves with a uniform acceleration of 4 m/s^2 for a time interval of 10 s, so the average velocity of the body through its whole journey equals ....

(a) 35 m/s (b) 30 m/s (c) 25 m/s (d) 20 m/s

14 A rescue plane flies at a constant vertical height (h) of 500 m above the surface of the sea with constant velocity (v) of 55 m/s, if the plane drops a rescue capsule for a person at horizontal distance x as shown in the opposite figure, what should be the distance x to make the capsule reach this person? ($g = 10\ m/s^2$)

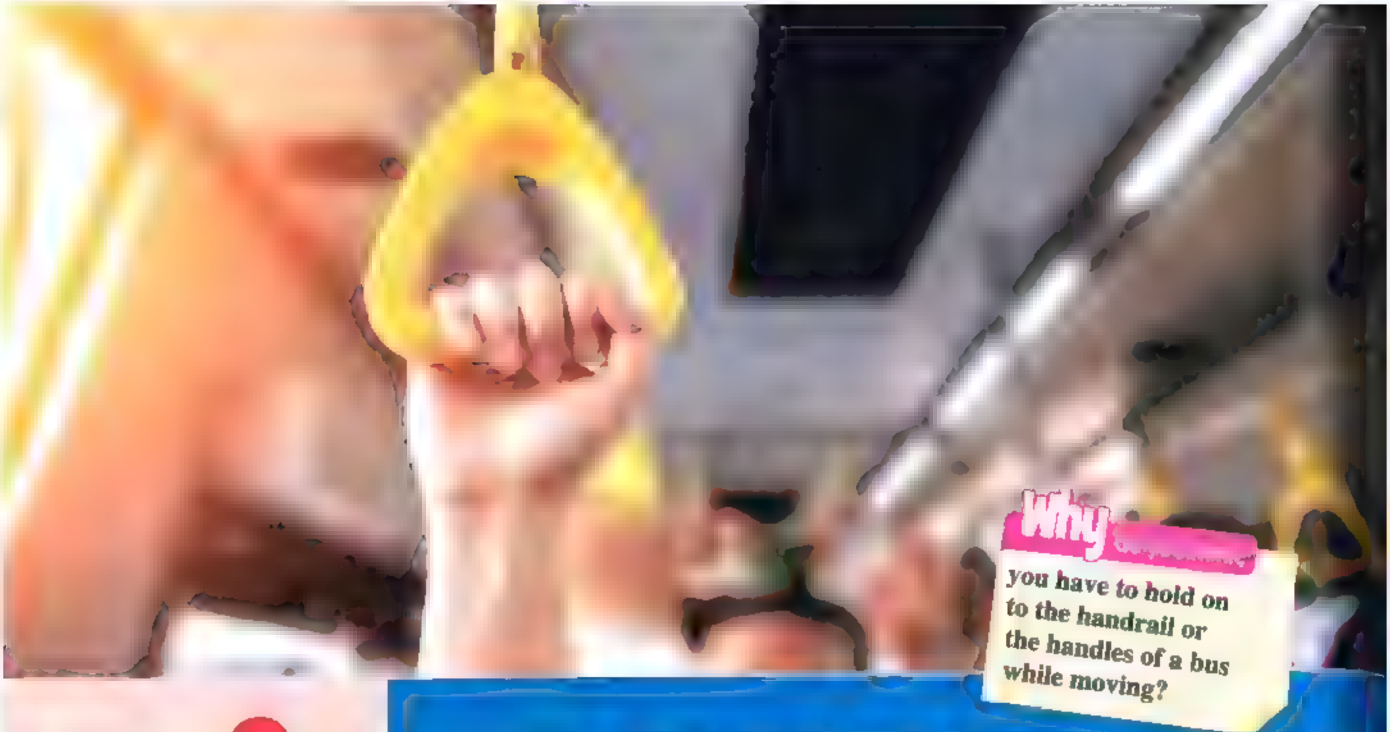


ⓐ 2750 m ⓑ 1000 m ⓒ 550 m ⓓ 389 m

[illegible] Answer the following questions

15 A body moves with an acceleration a and after covering a distance d its velocity becomes v_f **Mention** the conditions of applying the following equation on this body; $v_f^2 = 2\ ad$

16 A ball is projected horizontally from a certain height with a speed v and at the same moment another ball falls freely from the same height to hit the ground at a speed 2 v. By neglecting the air resistance, **which** of the two bodies reaches the ground first? **Explain your answer.**



Chapter 3

Force and Motion

We have previously described the motion of bodies by studying the concepts of velocity and acceleration without considering the causes of motion and in this chapter we will study these causes (force).

Force

Force :

It is the external influence that affects an object to change its state of motion or direction.

Examples :

- The force exerted by your muscles helps to pull or push things.
- The force of the car engine helps the car to start moving or to increase its velocity.
- The force of brakes acts to stop the moving car.
- The friction is the force that resists motion when the surface of one object comes in contact with the surface of another.
- Invisible forces that work all around us like gravity, electromagnetism and nuclear forces.

Distinguished Scientists

Galileo and Newton

Appreciation to Galileo and Newton for their contribution in formulating a reliable theory of motion by the end of the seventeenth century where they explored and explained the motion of bodies and its causes.

Galileo

Isaac Newton

Newton's Laws of Motion

Newton has developed three laws to explain and interpret the motion of objects when a force or a group of forces affect them and we will study in the following section each one of these laws separately.

EKB

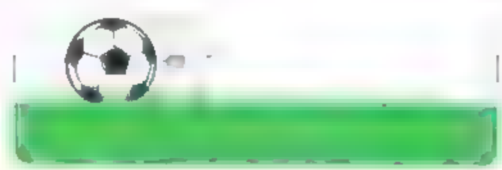
First ● Newton's first law

- When a ball is placed on the ground, it remains stationary in its position unless the player acts on it and changes its state (It doesn't change its state unless acted upon by an external force).

The static body stays at rest

The static body moves when an external force acts on it

- When the ball is kicked on the ground, it rolls for a certain distance, then slows down till it stops by the effect of frictional forces between the ball and the ground that resist the rolling of the ball (**friction** is an external force that acts to change the object's state).
  If these frictional forces do not exist, the ball will keep moving at a uniform velocity in a straight line and will not stop.



The moving body stops when an external force acts on it (frictional force)

i.e. The body needs a force to change its state from rest to motion or from motion to rest but it doesn't need a force to keep its state (of rest or motion with a constant velocity in a straight line).

- From the previous, we can conclude Newton's first law of motion as follows:

Newton's first law of motion :

"A static object keeps its state of rest and a moving object keeps its state of motion at a uniform velocity in a straight line unless acted upon by a resultant (net) force that changes its state".

- The mathematical formula that expresses Newton's first law:

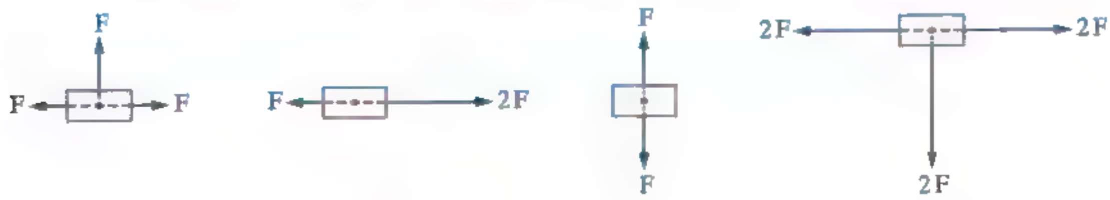
$$\Sigma \vec{F} = 0$$

The symbol (Σ) is pronounced sigma and it means "resultant".

i.e. If a number of forces act on an object, they may cancel the effect of each other and their resultant ($\Sigma \vec{F}$) equals zero. Thus, acceleration (a) = 0 and no change happens in the object's velocity either being static (v = 0) or dynamic (v = constant).

Example

The following figures represent four static bodies, if they get affected by several forces as shown in the following figures, which one of these bodies remains static?



ⓐ ⓑ ⓒ ⓓ

Solution

Clue

In order to keep the body at rest, the resultant of forces that act on it should equal zero $(\Sigma \vec{F} = 0)$

ⓐ $F_x = F - F = 0$, $F_y = F$ $\therefore \Sigma\vec{F} \neq 0$

ⓑ $F_x = 2F - F = F$, $F_y = 0$ $\therefore \Sigma\vec{F} \neq 0$

ⓒ $F_y = F - F = 0$, $F_x = 0$ $\therefore \Sigma\vec{F} = 0$ $\therefore$ The body remains static.

ⓓ $F_x = 2F - 2F = 0$, $F_y = 2F$ $\therefore \Sigma\vec{F} \neq 0$

$\therefore$ **The correct choice is ⓒ.**

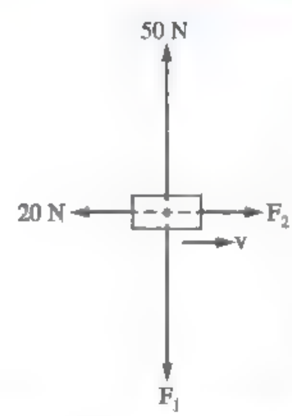
What if these bodies were moving with uniform velocity when they get affected by the same forces as the previous case, **which** one of them keeps moving with its same velocity?

1 Test yourself

Answered

Choose the correct answer:

A body moves with uniform velocity v in a straight line under the effect of four forces as in the opposite figure, then the magnitudes of $\vec{F_1}$ and $\vec{F_2}$ are ....



	F_1	F_2
a	20 N	20 N
b	20 N	50 N
c	50 N	20 N
d	50 N	50 N

Inertia

⊙ The concept of inertia can be clarified through the following examples:

▶ The coin gets dropped into the cup when the card is rapidly flicked,

▶ because the static body (coin) tends to keep its state of rest.

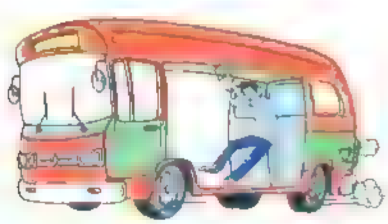
▶ The motorcyclist is thrown forwardly when the motorcycle collides with a barrier,

▶ because the moving object (motorcyclist) tends to keep its state of motion.

▶ The continuity of the fan motion for an interval of time when the electric current is turned off,

▶ because the moving object (blades of the fan) tends to keep its state of motion.

▶ When a bus moves forward suddenly from rest or when its velocity increases suddenly, the passengers tend to fall backward,



▶ because the body (passengers) tends to keep its state of rest.

▶ When the bus stops suddenly or when its velocity decreases suddenly, the passengers tend to fall forward,

▶ because the body (passengers) tends to keep its state of motion.

Inertia :

It is the tendency of an object to keep either its state of rest or state of motion at its original velocity uniformly in a straight line.

Or

It is the property of objects to resist the change of its static or dynamic state.

Notes :

(1) **Newton's first law is known as the law of inertia** because the object can't change its state of rest or motion in a straight line with a uniform velocity by itself.

(2) Seatbelt should be fastened when driving to reduce the effect of inertia during car crashes and protect passengers from being hurt.

(3) **Space rockets do not consume fuel to keep moving when being out from the Earth's gravity** because inertia keeps them moving at a uniform velocity in a straight line.

Test yourself

Answered

If a train that moves with a large velocity stops suddenly, **in which direction** will a small bag that is placed under a chair move?

....

Second Newton's second law

It will be studied in the second term.

Third Newton's third law

To understand Newton's third law, we can use the following example:

When a metallic rod is used to hammer a wooden surface, the rod acts on the surface by a force and also the surface acts on the rod by a force in the opposite direction. If you don't think that, imagine that you are using a glass rod to hammer the wooden surface which leads to breaking the glass rod due to hammering. The force that leads to breaking the glass rod is the same force by which the wooden surface acts on the glass rod.

⊙ We can observe the effect of action and reaction forces frequently in our daily life, such that when:

1

A person that sits on a moving chair, pushes the wall (action), the chair moves backwards (reaction).

2

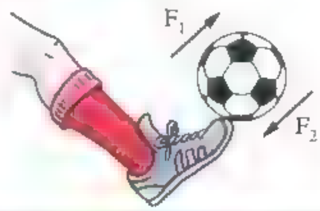
A bullet gets fired from a rifle (action), the rifle recoils backwards (reaction). Because of this the soldier should mount the rifle back firmly to his shoulder.

3

Inflating a balloon and leaving it free, the trapped air rushes out from the opening of the balloon in a certain direction (action) causing the balloon to move in the opposite direction (reaction).

4

Kicking a ball the foot act on the ball by a force (action) and the ball acts on the foot by a force in the opposite direction (reaction).



From the previous, we can conclude that this law is related to two mutual forces between two different bodies. If we consider the first force ($\overrightarrow{F_1}$) as an **action**, the second force ($\overrightarrow{F_2}$) is considered as a **reaction** equal in magnitude and opposite in the direction and from this we can conclude Newton's third law as follows:

EKB

Newton's third law of motion :

"When an object acts on another object by a force, the second object reacts with an equal force on the first object in a direction opposite to that of action".

Or

"For every action there is a reaction equal in magnitude and opposite in direction".

⊙ The mathematical formula that expresses the Newton's third law : $\overrightarrow{F_1} = -\overrightarrow{F_2}$

The negative sign indicates that the two forces $\overrightarrow{F_1}$ and $\overrightarrow{F_2}$ act in opposite directions.

Notes :

(1) **No single force can exist in the universe** because action and reaction are paired forces; originate and vanish together.

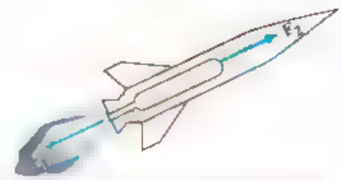
(2) **Although action and reaction forces are equal, they do not be at equilibrium (the resultant of the action and the reaction ≠ zero)** because the two forces act on different bodies and the equilibrium condition happens when the two equal forces act on the same body.

(3) Action and reaction are of the same type; if the action is a gravitational force, reaction is a gravitational force, as well.

(4) The action force and the reaction may not be perpendicular on the surface as in the opposite figure.

Technological Application:

- Launching a rocket is based on Newton's third law of motion because a huge amount of burning gases rushes down the rocket to generate a reaction that pushes the rocket upwards.

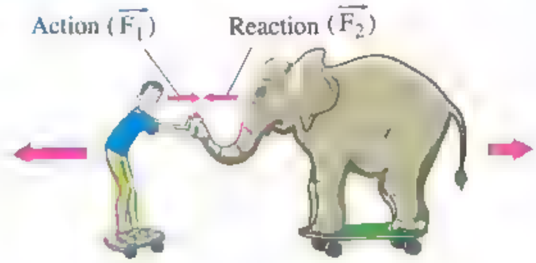


Example 1

Study the opposite figure, then answer the questions below:

(a) **What** is the relation between the force acting on the elephant and that on the man?

(b) **Why** are not action force that acts on the elephant and reaction force that acts on the man at equilibrium?



Solution

(a) The force acting on the elephant = – the force acting on the man, $\overrightarrow{F_1} = -\overrightarrow{F_2}$

(b) For equilibrium to take place between two forces, they must be equal in magnitude and opposite in the direction, having one line of action and acting on the same body. All these conditions are applied on action and reaction except the last one; since the action acts on the elephant's body and the reaction is on another body (the man).

What if the reaction force of the Earth on the elephant's skateboard is $\overrightarrow{F_3}$ and the reaction force of the Earth on the man's skateboard is $\overrightarrow{F_4}$, **are** these forces equal?

Example 2

What is the force responsible for moving the car (what makes the car move forward)?

Solution

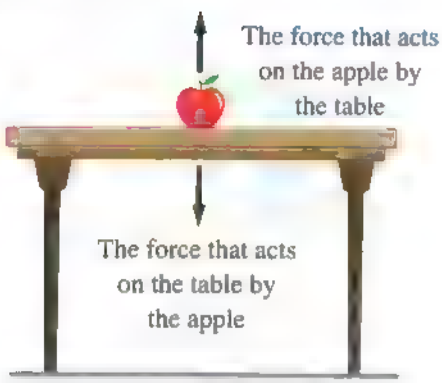
The friction force between the tyres of the car and the road is what makes the car move forward, where the tyres of the car pushes the ground backwards, so the ground pushes the tyres forward (the opposite direction) according to Newton's third law and the car moves forward.

What if the car is on a road that is covered with smooth snow, **will** the car move?

Example 3

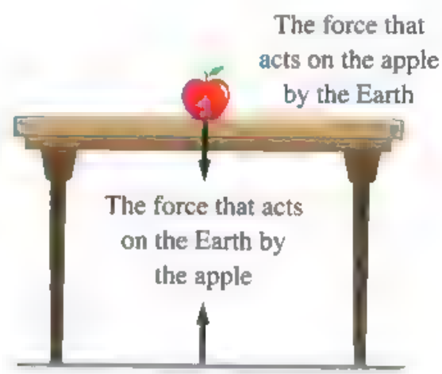
The opposite figure shows an apple that is placed in equilibrium on a table, what are the action and the reaction forces that act on the apple?

Solution



$\vec{F}_{\text{apple on table}} = -\vec{F}_{\text{table on apple}}$

(1)

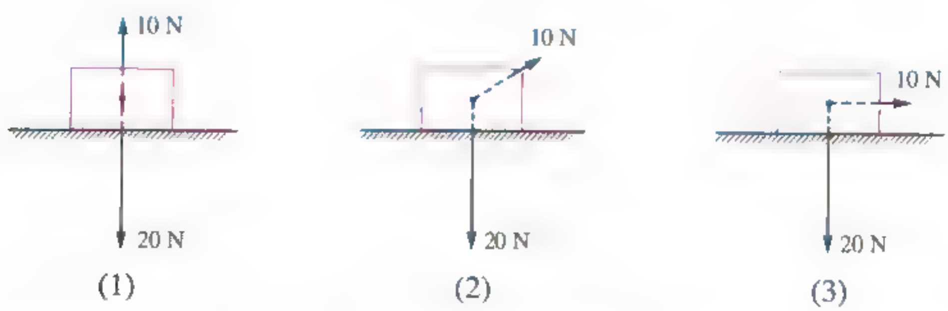


$\vec{F}_{\text{apple on Earth}} = -\vec{F}_{\text{Earth on apple}}$

(2)

Example 4

The following figures represent three identical boxes, the weight of each is 20 N and a tension force of 10 N acts on each of them, so the correct arrangement of the boxes according to the value of the reaction force that acts on the box by the surface is ......



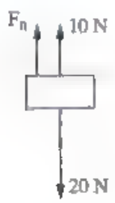
ⓐ (1) > (2) > (3) ⓑ (3) > (2) > (1) ⓒ (2) > (1) > (3) ⓓ (2) > (3) > (1)

Solution

Clue

The box remains touching the surface in the three cases because the acting vertical force in the three cases is less than the weight of the box, so $\Sigma \overrightarrow{F_y} = 0$ and to obtain the reaction force by which the surface acts on the box, we draw a diagram for the forces vectors in each case and solve the equation $\Sigma \overrightarrow{F_y} = 0$

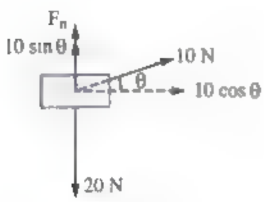
(1)



$20 = F_n + 10$

$F_n = 20 - 10 = 10$ N

(2)

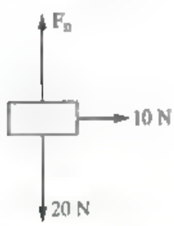


$20 = F_n + 10 \sin \theta$

$F_n = 20 - 10 \sin \theta$

$20 > F_n > 10$

(3)



$F_n = 20$ N

∴ **Box (3) > Box (2) > Box (1)**

∴ **The correct choice is ⓑ.**

What if you are asked to mention the case at which the reaction force by **which** the surface acts on the box is greater than its weight?

3 Test yourself

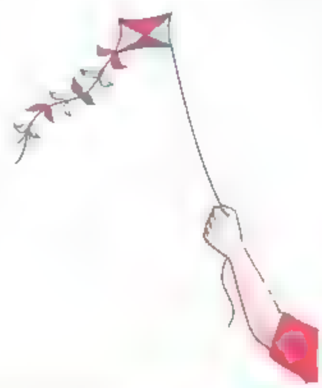
Answered

Choose the correct answer:

1 A truck of mass 10^4 kg hits a car of mass 10^3 kg. If the force that acts on the car by the truck during the collision is $\vec{F}$, then the force that acts on the truck by the car is ....

ⓐ $0.1 \vec{F}$ ⓑ $-0.1 \vec{F}$ ⓒ $\vec{F}$ ⓓ $-\vec{F}$

2 If we consider that the force of gravity that pulls the kite downwards is the action force, so which of the following represents the reaction force?



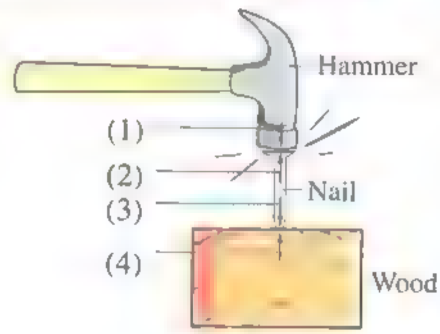
ⓐ The force of pulling the kite by the hand.

ⓑ The force of pulling the hand by the kite.

ⓒ The force of lifting the kite by the air.

ⓓ The force of attracting the Earth by the kite.

3 The opposite figure represents a hammer that hammers a nail that is placed on a piece of wood and the forces (1), (2), (3) and (4) represent the forces of action and reaction during the process of hammering, so the nail can penetrate the wood when ....



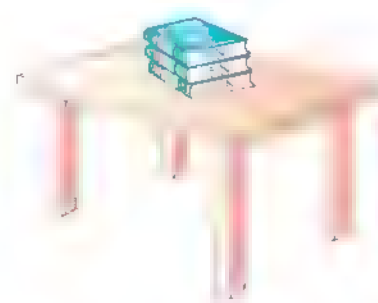
ⓐ force (1) > force (2)

ⓑ force (2) > force (3)

ⓒ force (3) > force (4)

ⓓ force (4) > force (1)

4 The opposite figure represents three books (x, y, z) which are placed on a table, what is the value of the reaction force of book z that acts on book y?



ⓐ 4 N　　ⓑ 5 N

ⓒ 9 N　　ⓓ 10 N

Questions on Chapter 3

Force and Motion

The questions signed by * are answered in detail.

To watch videos of how to solve questions use the App

GPS

Interactive test

Multiple choice questions

Newton's first law

1. The continuity of rotation of the blades of the electric fan for a period of time although the electric current is turned off is due to ....

   (a) inertia
   (b) the heavy mass of the fan blades
   (c) the stored amount of electric current
   (d) the equilibrium of the acting forces

2. When a bus moves suddenly from rest in the forward direction, the bus passengers get thrown ....

   (a) forward
   (b) backward
   (c) to the right
   (d) to the left

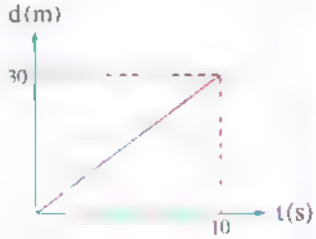
3. When a bus that is moving in a straight line stops suddenly, the bus passengers get thrown ....

   (a) forward
   (b) backward
   (c) to the right
   (d) to the left

4. A person tried to push a box of mass 50 kg that is placed on a rough horizontal surface as in the opposite figure but he couldn't, so the resultant of the acting force on the box equals ....

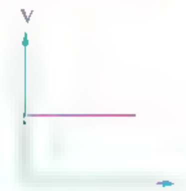
   (a) zero
   (b) 25 N
   (c) 50 N
   (d) 500 N

5. The opposite graph represents the relation between the displacement (d) and time (t) of a body of mass 10 kg that moves in a straight line, so the acting resultant force on the body equals ....



   (a) 30 N
   (b) 300 N
   (c) 3 N
   (d) 0

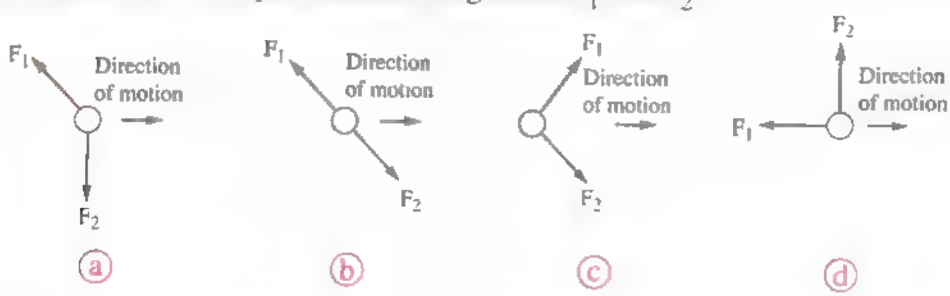
6 * The opposite graph represents the relation between the velocity (v) and the time (t) of a body that is affected by three forces F_1, F_2 and F_3 where the direction of each F_1 and F_2 is opposite to the direction of F_3, so which of the following equations is correct?



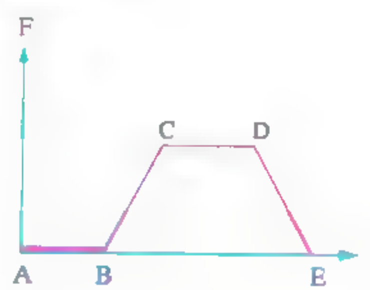
ⓐ $F_3 = F_1 + F_2$ ⓑ $F_1 = F_2 = F_3$

ⓒ $F_1 = F_2 + F_3$ ⓓ $F_2 = F_1 + F_3$

7 * Which of the following figures represents a body that moves with a uniform velocity v under the effect of two equal forces in magnitude F_1 and F_2?



8 * The opposite graph represents the relation between the resultant force acting on a body and the time, so the time interval in which the body moves with uniform velocity is ....

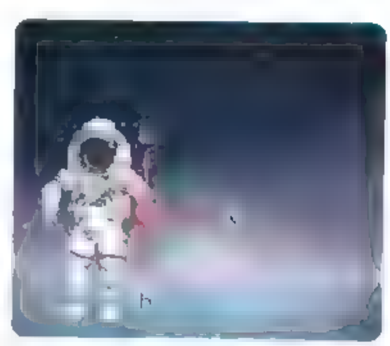


ⓐ AB   ⓑ BC

ⓒ CD   ⓓ DE

Newton's third law

9 * If an astronaut who is floating in the space projected a small object in the direction of a as in the opposite figure, the astronaut will ....



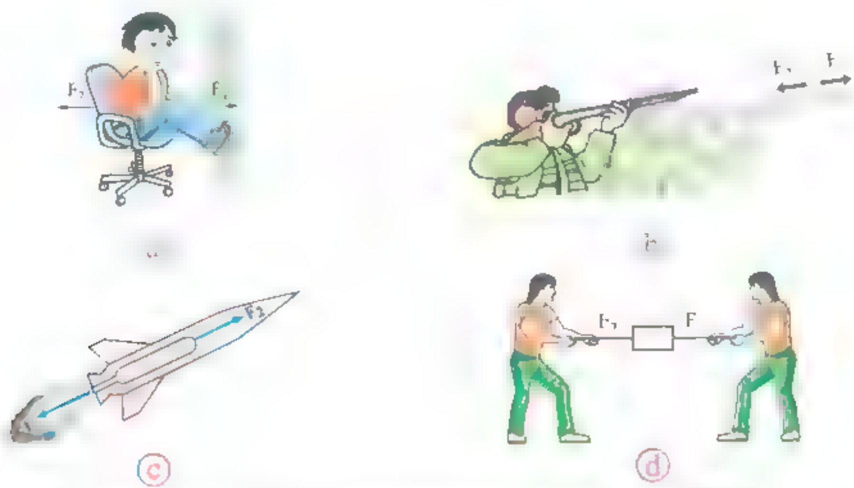
ⓐ move in the direction of a

ⓑ move in the direction of b

ⓒ move in the direction of c

ⓓ not move

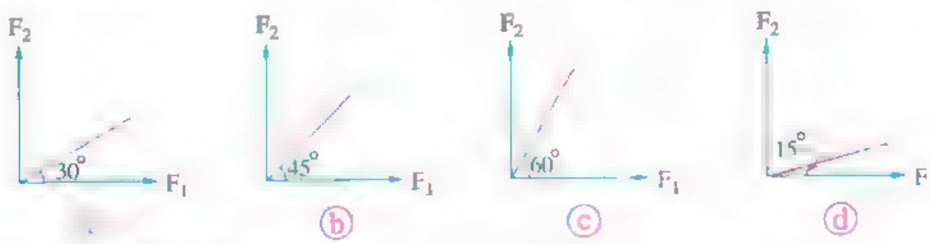
10 In which of the following figures the two forces of equal magnitudes F_1 and F_2 may cause equilibrium?



11 When inflating a balloon and leaving it free to release the air from it, the balloon moves ....

(a) in the direction of the air rush
(b) in a direction right to the direction of the air rush
(c) in the opposite direction of the air rush
(d) in a direction left to the direction of the air rush

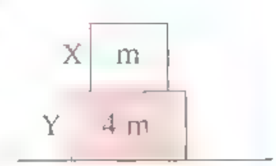
12 Which of the following graphs represents the relation between the magnitude of the reaction force (F_2) and the magnitude of the action force (F_1) when drawn by the same drawing scale?



13 ✱ If a body (x) acts on another body (y) by a force of 9 N, then the reaction force of body y on body x equals ....

(a) 1 N (b) − 9 N (c) 0 (d) 9 N

14 ✱ The opposite figure shows body X that is placed above body Y and both of them are in rest. If body X acts on body Y by a force F downwards, then body Y acts on body X by a force ....



(a) F upwards (b) 4 F downwards (c) $\frac{1}{4}$ F upwards (d) F downwards

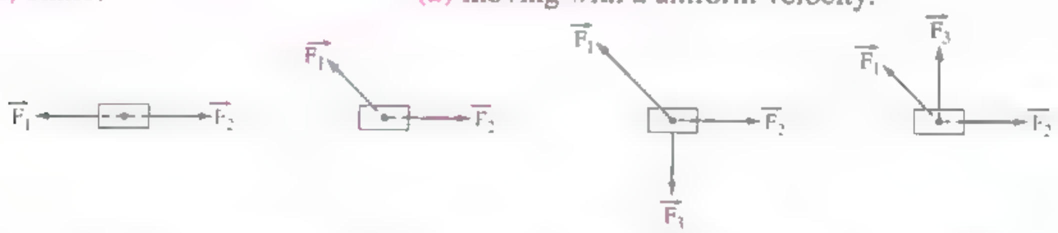
Essay questions

1. Can a body be in a state of equilibrium when it is affected by a single force? **Explain.**

2. When you are inside a plane at the night in a quiet weather, you do not feel its motion although its velocity may be 800 km/h. **Explain.**

3. **Explain the following sentences:**
   (1) The bicycle continues to move for a while after stopping the paddling.
   (2) Newton's first law is known as the law of inertia.
   (3) The falling of passengers backwards if the car suddenly moves forwards.
   (4) • Passengers in a bus fall forwards when it stops suddenly.
   • Motorcycle rider flies off the motorcycle when it hits an obstacle.
   (5) A space rocket does not need to consume fuel after being moved away from the Earth's gravity.
   (6) The soldier mounts the back of the rifle into his shoulder cavity.

4. In which of the following cases the body could be:
   (1) static. (2) moving with a uniform velocity.



(a) (b) (c) (d)

5. From the opposite figure:
   What is the physical property upon which the magician depends in doing his trick when he withdraws the mattress without letting the cups fall from table?

6. In the opposite figure **what happens when** the card is pulled suddenly (rapidly)? **And why?**

7. **Explain why** car manufacturing companies have added safety belts to each car.

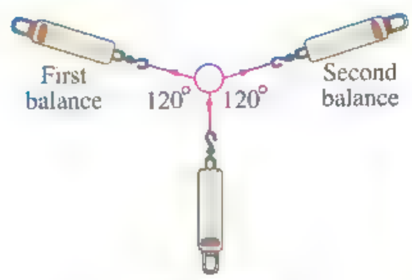
8. Mention the action and reaction pair of forces in each of the following cases:
   (1) A man moves in the street. (2) A catches the football.
   (3) A window is closed due to the wind blowing.

Questions that measure high levels of thinking

Answered in detail

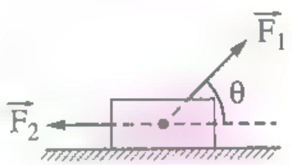
Choose the correct answer:

1 In the opposite figure, there are three spring balances that are in equilibrium state if the reading of each of the first and the second balance is 100 N, so the reading of the third balance is ....



(a) 0
(b) 25 N
(c) 50 N
(d) 100 N

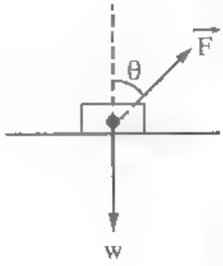
2 The opposite figure shows a box that moves horizontally with a constant velocity on a frictionless surface under the effect of two forces $\overrightarrow{F_1}$, $\overrightarrow{F_2}$. If we want to keep the box moving with a constant velocity while reducing the angle θ without changing the magnitude of force $\overrightarrow{F_1}$, we should ....



(a) increase the magnitude of $\overrightarrow{F_2}$
(b) decrease the magnitude of $\overrightarrow{F_2}$
(c) not change the magnitude of $\overrightarrow{F_2}$
(d) reverse the direction of $\overrightarrow{F_2}$

Answer the following questions :

3 In the opposite figure, a force F acts on a body of weight w which is placed on a surface, **mention two methods** to increase the reaction force that acts on the body by the surface.



Test on Chapter 3

Force and Motion

Choose the correct answer:

1 If the Earth affects your body by a force of 600 N, your body affects the Earth by a gravitational force of magnitude ....

(a) zero
(b) less than 600 N
(c) 600 N
(d) more than 600 N

2 If the resultant force acting on a moving body vanished, it means that its .... vanished.

(a) mass
(b) velocity
(c) acceleration
(d) displacement

3 A car moves on the highway with uniform velocity of 120 km/h under the effect of pushing force F_1 as well as the frictional force F_2, so ....

(a) $F_1 = F_2 \neq 0$
(b) $F_2 < F_1$
(c) $F_2 > F_1$
(d) $F_2 = F_1 = 0$

4 Which of the following statements doesn't apply on the action and the reaction forces?

(a) The magnitude of action force = The magnitude of reaction force
(b) Action force is opposite to reaction force.
(c) Action force and reaction force are acting on the same body.
(d) Action force and reaction force are acting on two different bodies.

5 A ship moves towards the south with uniform velocity of 3 m/s in a straight line when the resultant force on the ship is .... ($g = 10\ m/s^2$)

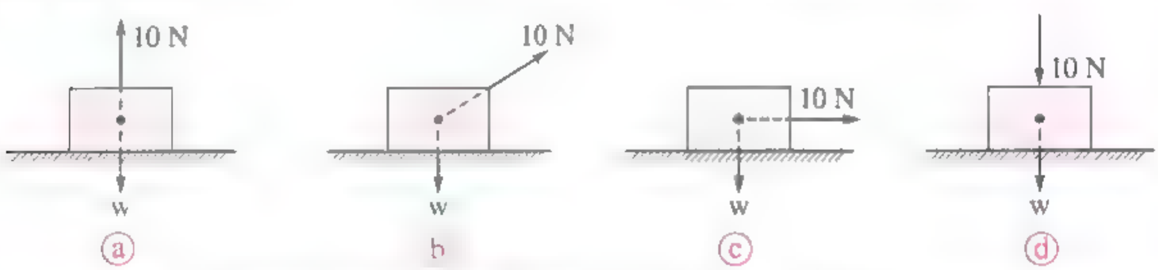
(a) towards the north
(b) towards the south
(c) equal to 30 N
(d) equal to zero

6 A static book that is placed on a table is acted upon by a force downwards, so the reaction force for this force is ....

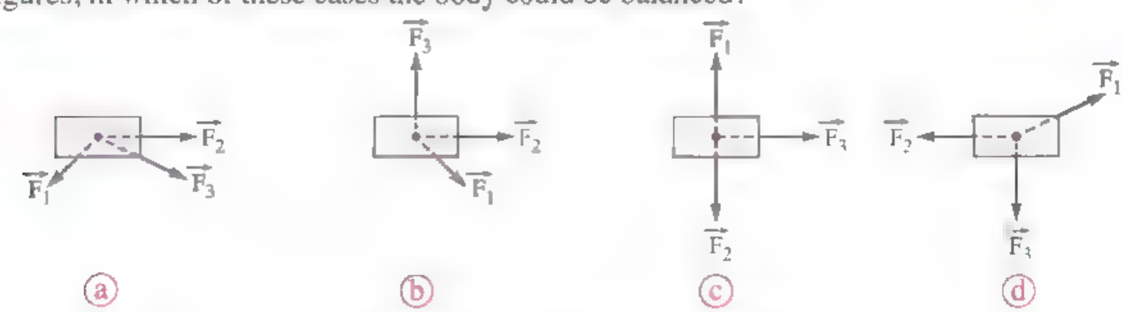
(a) the force that acts on the book by the Earth
(b) the force that acts on the book by the table
(c) the force that acts on the table by the Earth
(d) the force that acts on the Earth by the book

7 A bus was stopping at a traffic sign when another bus hit it rapidly from the back, so which of the following figures describes the motion of the passengers inside the two buses during the collision?

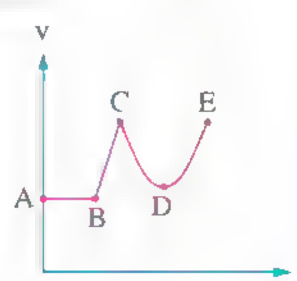
8 A person affects a box of weight w placed on a horizontal plane surface by a force of 10 N, in which of the following cases the reaction force by which the surface affects the box is greater?



9 Three forces $\vec{F}_1$, $\vec{F}_2$ and $\vec{F}_3$ affect a body in four different cases as shown in the following figures, in which of these cases the body could be balanced?



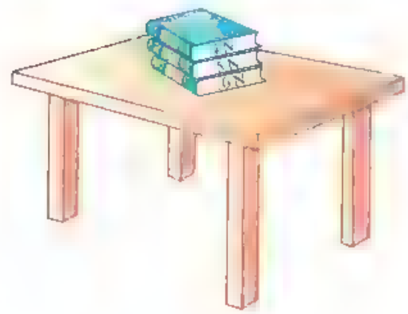
10 The opposite figure represents a graph of velocity versus time for a body moving in a straight line, so the interval in which the net force affecting the body equals zero is ....



(a) AB (b) BC

(c) CD (d) DE

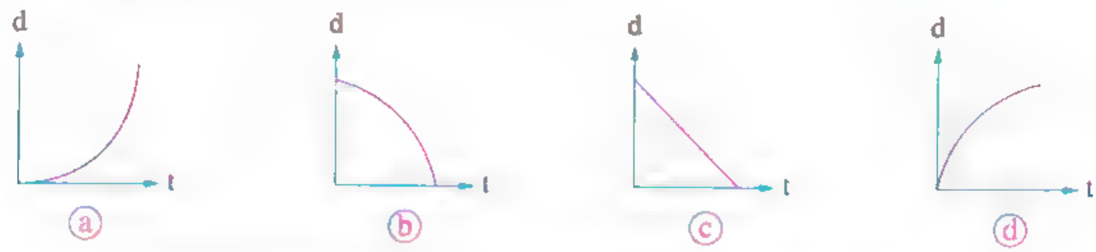
11 Three books x, y and z of weights 4 N, 5 N and 10 N respectively, are stable on a horizontal table surface as shown in the opposite figure, what is the magnitude of the reaction force of the table surface on book z?



(a) 5 N (b) 9 N

(c) 10 N (d) 19 N

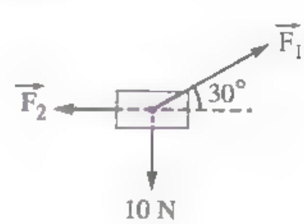
12 Which of the following figures possibly represents the graph of displacement versus time for a body on which the net force equals zero?



13 A book is being stable on a table which in turn is standing on a floor, if the floor affects the table by a force $\vec{F}_1 = 70$ N and the book affects the table by a force $\vec{F}_2 =$ 5 N, so the force by which ....

	The table affects the floor	The table affects the book
(a)	70 N	– 5 N
(b)	– 70 N	– 5 N
(c)	70 N	5 N
(d)	– 70 N	5 N

14 The opposite figure illustrates three forces acting on a static body, so the magnitudes of the two forces $\vec{F}_1$ and $\vec{F}_2$ respectively are ...., ...



(a) 10 N, $10\sqrt{3}$ N

(b) 20 N, $10\sqrt{3}$ N

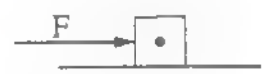
(c) 10 N, $20\sqrt{3}$ N

(d) 20 N, $20\sqrt{3}$ N

Answer the following questions

15. From your previous study for Newton's third law, **suggest a method** for a spacecraft to change its direction outside the Earth atmosphere.

16. In the opposite figure, a force F acts horizontally on a body which is placed on a horizontal surface, **will** the reaction force which acts on the body by the surface increase when increasing the magnitude of force F? **And why**?



Accumulative Test on **Units 1 & 2**

Choose the correct answer

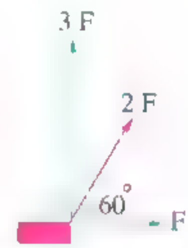
1. If the dimensional formula of X is $M^{-1}L^{2}T$ and the dimensional formula of Y is $M^{0}L^{3}T^{2}$, then the dimensional formula of (2 X – Y) is ....

ⓐ $M^{-2}LT^{0}$ ⓑ $M^{-1}L^{2}T$ ⓒ $M^{0}L^{3}T^{2}$ ⓓ undefined

2. If the density of a body is (100 ± 10) kg/m^3 and its volume is (30 ± 3) m^3, then its mass equals .... (Knowing that: Density = $\frac{\text{Mass}}{\text{Volume}}$)

ⓐ (3000 ± 600) kg ⓑ (130 ± 600) kg
ⓒ (3000 ± 30) kg ⓓ (130 ± 30) kg

3. From the opposite figure:
The resultant of the three forces acting on the body is ....



ⓐ F ⓑ $\sqrt{3}$ F
ⓒ 5.13 F ⓓ 6 F

4. A train was moving in a straight railway where it covered one third of the distance with a speed of 25 km/h and the remaining distance was covered by a speed of 75 km/h, so the average speed of this train is .... km/h.

ⓐ 30 ⓑ 45 ⓒ 50 ⓓ 65

5. If the acceleration and the velocity of a body have different directions, then ....

ⓐ the instantaneous velocity equals the average velocity
ⓑ the velocity of the body increases with time
ⓒ the velocity of the body decreases with time
ⓓ the displacement vanishes

6. An object moves from point x to point y in 20 s, where the velocity at x = 50 km/h and the velocity at y = 5.56 m/s, so the average acceleration of this object is ....

ⓐ 5.4×10^3 km/h^2 ⓑ -5.4×10^3 km/h^2
ⓒ 1.5×10^3 km/h^2 ⓓ -1.5×10^3 km/h^2

7. If a stone was thrown at velocity 96 m/s from the edge of a well to reach the bottom 3 s later, then the well depth is .... ($g = 9.8\ m/s^2$)

ⓐ 220.9 m ⓑ 332.1 m ⓒ 300.4 m ⓓ 426.2 m

8. Two identical projectiles were projected at 200 km/h, the 1st at an angle 60° to the horizontal while the 2nd one is at angle of 60° to the vertical. Which projectile reaches a greater horizontal range?

ⓐ The 1st one.
ⓑ The 2nd one.
ⓒ They have equal ranges.
ⓓ Not enough information to indicate which one.

9. If the resultant force acting on a moving body equals zero, this means that its .... must be constant.

ⓐ displacement
ⓑ velocity
ⓒ speed
ⓓ all of the previous

10. The idea of launching a rocket is based on the law of ....

ⓐ inertia
ⓑ reaction
ⓒ motion
ⓓ conservation of energy

11. If a body moves on a circle of radius 2 m taking 2 s to make $\frac{1}{4}$ revolution, so the speed and the velocity of the body during that interval respectively equal ....

ⓐ $\frac{\pi}{2}$ m/s, $2\sqrt{2}$ m/s
ⓑ $\frac{\pi}{2}$ m/s, $\sqrt{2}$ m/s
ⓒ π m/s, $\sqrt{2}$ m/s
ⓓ $\sqrt{2}$ m/s, $\frac{\pi}{2}$ m/s

12. If a body moved with uniform velocity of 4 m/s for 8 s, then moved with a uniform acceleration of 4 m/s^2 for 6 s, the total displacement covered by the body during both intervals equals ....

ⓐ 32 m ⓑ 96 m ⓒ 128 m ⓓ 160 m

13. If a train slows down at a deceleration of 2 m/s^2, the time required for the train to change its velocity from 72 km/h to 13 km/h will equal ....

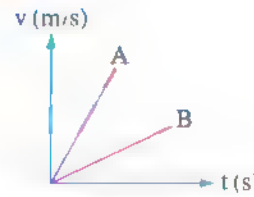
ⓐ 3.6 s ⓑ 8.2 s ⓒ 20 s ⓓ 29.5 s

14. A projectile is fired from the ground with a velocity of 20 m/s at an angle of 65° to the horizontal, so the time taken by the projectile to return back to the ground equals .... ($g = 10\ m/s^2$)

ⓐ 3.6 s ⓑ 8.2 s ⓒ 20 s ⓓ 29.5 s

Second | Answer the following questions

15 The opposite diagram illustrates two moving objects.



According to the graph:

(a) **Which** object has started motion from rest?

(b) **Which** object has greater acceleration?

16 A body falls from a tower so that it takes 6 s to reach the bottom, **find:**

(a) The height of the tower.

(b) The velocity at the bottom. $(g = 10\ m/s^2)$

Monthly Tests

(According to the Standards of the Ministry of Education)

Test 1 For the first month

Choose the correct answer (1 : 7) :

1. Which of the following pairs of quantities represent two fundamental physical quantities?

   (a) Force and displacement (b) Absolute temperature and speed.

   (c) Amount of substance and time. (d) Luminosity and volume.

2. The opposite figure illustrates two vectors $\vec{A}$, $\vec{B}$, so the ratio between their scalar product and the magnitude of their vector product equals ....

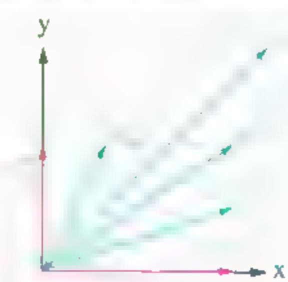
   (a) $\frac{1}{\sqrt{3}}$ (b) $\frac{\sqrt{3}}{1}$ (c) $\frac{1}{2}$ (d) $\frac{2}{1}$

3. A solid cylinder that has a base radius (r) of 5 cm and a height (h) of 20 cm is made of iron that has a density of 7800 kg/m^3, so the mass of the cylinder equals ....

   $\left(\text{Given that: the volume of a cylinder} = \pi\, r^2 h,\ \text{density} = \frac{\text{mass}}{\text{volume}},\ \pi = \frac{22}{7}\right)$

   (a) 1.23×10^2 g (b) 2.45×10^3 g (c) 1.23×10^4 g (d) 1.23×10^5 g

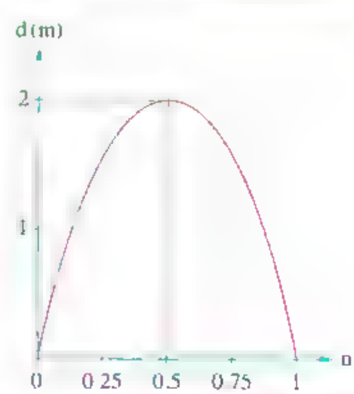
4. In the opposite figure, which of the vectors $\vec{F}_1$, $\vec{F}_2$, $\vec{F}_3$ or $\vec{F}_4$ represents the resultant of the two components $\vec{F}_x$ and $\vec{F}_y$?



   (a) $\vec{F}_1$ (b) $\vec{F}_2$

   (c) $\vec{F}_3$ (d) $\vec{F}_4$

5. The opposite graph represents the relation between the magnitude of displacement (d) for a body moving in a circular path and the number of revolutions (n) made by the body, so the distance covered by the body through a complete revolution equals ....



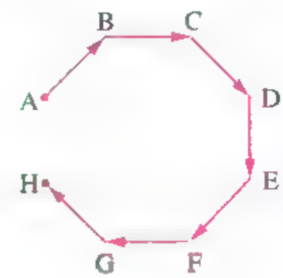
   (a) 2 m (b) π m

   (c) 4 m (d) 2π m

6 If $x = (100 \pm 0.01)$ m and $y = (200 \pm 0.03)$ m, the absolute error in calculating the quantity $(y - x)$ equals ....

(a) 0.04 m (b) 0.03 m (c) 0.02 m (d) 0.01 m

7 The opposite figure illustrates the path of a body while moving on an octagon of side length 10 m, so the total displacement of the body equals ....



(a) 70 m in direction $\overrightarrow{AH}$

(b) 70 m in direction $\overrightarrow{HA}$

(c) 10 m in direction $\overrightarrow{AH}$

(d) 10 m in direction $\overrightarrow{HA}$

Answer the following questions (8 : 10) :

8 Given that the measuring unit of acceleration is m/s^2 and its dimensional formula is L^xT^y, **what** are the values of x and y?

....

....

9 Two vectors $\vec{A}$ and $\vec{B}$ have a resultant vector $\vec{C}$. The horizontal and vertical components of vector $\vec{A}$ respectively are 3 units and 4 units while the horizontal and vertical components of vector $\vec{B}$ respectively are 6 units and 8 units, **calculate** the magnitude of vector $\vec{C}$.

....

....

....

10 **Why**, when making a measurement, is it preferable to repeat the measurement several times then calculating the average of the obtained measurements?

....

....

Test 2

For the first month

Choose the correct answer (1 : 7) :

1 Which of the following processes is an indirect measurement?

(a) Measuring the mass of an object using a scale.

(b) Measuring the volume of a liquid using a graduated cylinder.

(c) Measuring the area of a room using meter tape.

(d) Measuring the density of a liquid using a hydrometer.

2 If x and y are two physical quantities where the dimensional formula of x is LT^{-2} and the dimensional formula of y is ML^{-1}, which row of the following table represents the dimensional formulae of the shown quantities?

	$\frac{y}{x}$	$x + y$
a	MLT^2	MLT^{-2}
b	$ML^{-2}T^{-2}$	MLT
c	MLT^2	impossible
d	$ML^{-2}T^2$	impossible

3 If the scalar product of two vectors equals two thirds of the magnitude of their vector product, the angle between the two vectors equals ....

(a) 30° (b) 56.3° (c) 33.69° (d) 45°

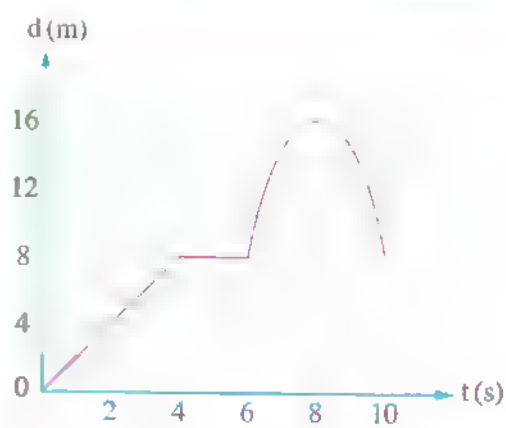
4 The opposite graph represents the relation between displacement (d) and time (t) for a body moving in a straight line, so the total distance covered by the body through the 10 s equals ....

(a) 0

(b) 8 m

(c) 16 m

(d) 24 m



5. The opposite figure illustrates two forces $\vec{F}_1$ and $\vec{F}_2$ acting on a body, so the net force affecting the body equals ....

(a) 10 N in the direction of $\vec{F}_2$
(b) 10 N in the direction of $\vec{F}_1$
(c) 2 N in the direction of $\vec{F}_2$
(d) 2 N in the direction of $\vec{F}_1$

6. Two vectors have equal magnitudes, the angle between them is 60° and their scalar product is 9 units, the magnitude of each of the two vectors equals ....

(a) 3 units
(b) $3\sqrt{2}$ units
(c) 6 units
(d) 9 units

7. Pressure is measured in the units of pascal which is equivalent to $kg.m^{-1}.s^{-2}$ while electric current intensity is measured in the units of ampere which is equivalent to coulomb/second, then which of the following statements is correct?

(a) Pressure is a fundamental quantity, while electric current intensity is a derived quantity.
(b) Pressure is a derived quantity, while electric current intensity is a fundamental quantity.
(c) Both pressure and electric current intensity are fundamental quantities.
(d) Both pressure and electric current intensity are derived quantities.

Answer the following questions (8 : 10) :

8. A vector $\vec{A}$ makes an angle of 30° with its vertical component while its horizontal component equals 5 units, **calculate** the magnitude of vector $\vec{A}$.

....

....

9. The similarity of the dimensional formulae of both sides of an equation doesn't prove that the equation is correct. **Explain.**

....

....

10. An object moves in a straight line with a uniform speed such that it covers a distance of (10 ± 0.1) m through (5 ± 0.1) s, **calculate** the speed of the object.

$\left(\text{Given that: speed} = \dfrac{\text{distance}}{\text{time}}\right)$

....

....

est 1 For the second month

·the correct answer (1 : 7) :

hich of the following represents a translational motion?

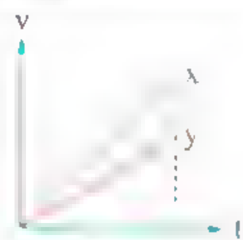
Motion of electrons around the nucleus. Motion of a bullet fired from a gun.

Motion of a fan blades. Motion of the Moon about itself.

ody started to move from rest in a straight line with a uniform acceleration to cover istance of 225 m through 15 s, so the acceleration of the body equals ....

) $3\ m/s^2$ (b) $2\ m/s^2$ (c) $1\ m/s^2$ (d) $0.5\ m/s^2$

e opposite graph represents the relation between velocity (v) and ie (t) for two students x and y moving in a straight line for a given ie interval, so which of the two students is moving with a greater :eleration? And which of them has covered a longer distance?



	Moving with a greater acceleration	Covered a longer distance
	Student x	Student x
	Student x	Student y
	Student y	Student x
	Student y	Student y

ar was travelling on a straight road with a uniform velocity v, when the car driver lied the brakes, the car got decelerated at a uniform rate of $2\ m/s^2$ and stopped ough 9 s, so velocity v equals ....

9 m/s (b) 18 m/s (c) 21 m/s (d) 27 m/s

ody started its motion from rest in a straight line at a uniform acceleration a so that velocity reached v after cutting a displacement d, so the velocity of the body after ing a displacement 3 d from the start of motion becomes ....

3 v (b) $\sqrt{3}$ v (c) 6 v (d) $\sqrt{6}$ v

ody is moving in a straight line with a uniform acceleration according to the relation 3 + 2 t, where (t) is the time of motion and it is measured in seconds and v_t is the ocity of the body and it is measured in meters/second, so the covered distance after from the start of motion equals ....

20 m (b) 25 m (c) 40 m (d) 60 m

7. The driver of a car that was moving on a straight road has noticed the red light at a distance of 120 m ahead when the speed of his car was 72 km/h, so he applied the brakes and the car moved with a negative acceleration of 2 m/s^2, hence which of the following statements is true?

(a) The car would exceed the red light by 20 m.

(b) The car would exceed the red light by 80 m.

(c) The car would stop before reaching the red light by 20 m.

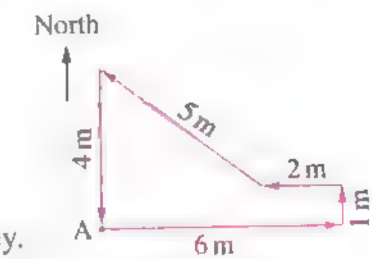
(d) The car would stop before reaching the red light by 80 m.

Answer the following questions (8 : 10) :

8. The opposite figure illustrates the motion of a body that started from point A to take a time interval of 9 s for covering the shown path, **calculate:**

(a) The magnitude of the average velocity of the body through the whole journey.

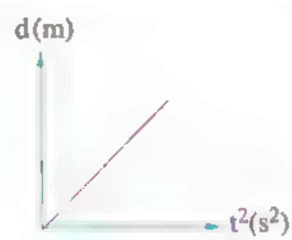
(b) The average speed of the body through the whole journey.

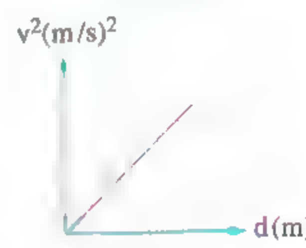


....

....

9. Both of the opposite graphs represent the motion of a body from rest in a straight line with a uniform acceleration (a), **so what** does the slope of the straight line represent in each graph?

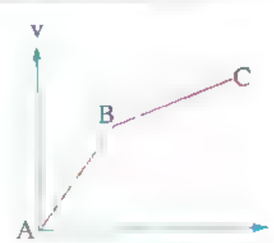




....

....

10. The opposite graph represents the relation between velocity (v) and time (t) for a body moving in a straight line, **compare with explaining** the magnitudes of the accelerations of the body motion through the two intervals AB and BC.



....

....

Test 2 For the second month

Choose the correct answer (1 : 7) :

1 A body is moving in a straight line such that it cuts equal displacements through equal time intervals, so this means that the body is moving with ....

(a) a uniform acceleration (b) an increasing acceleration

(c) a decreasing acceleration (d) zero acceleration

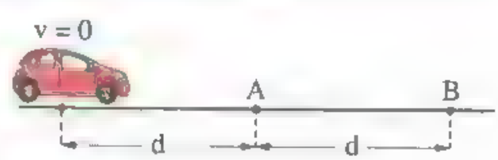
2 A body started its motion in a straight line with an initial velocity of 5 m/s, hence its average velocity through 10 s was equal to 20 m/s, so the uniform acceleration with which the body moved equals ....

(a) 3 m/s^2 (b) 6 m/s^2 (c) 7 m/s^2 (d) 9 m/s^2

3 If your father drove his car with a uniform speed of 90 km/h on a straight road while his friend drove his car on the same road from the same point and from the same instant with a uniform speed of 95 km/h to make a journey of length 50 km, so the time that his friend waits at the end of the journey till your father arrives with his car equals ....

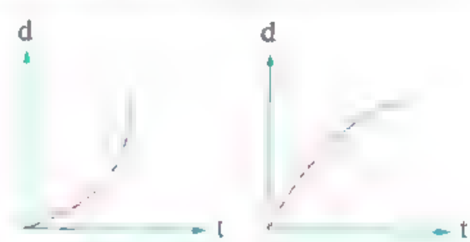
(a) 6 minutes (b) 3.7 minutes (c) 1.75 minutes (d) 0.029 minutes

4 In the opposite figure, a car starts its motion from rest in a straight line with a uniform acceleration to reach point A through time t_1 and to point B through time t_2 from the beginning of motion, so the ratio $\left(\frac{t_1}{t_2}\right)$ equals ....



(a) $\frac{1}{1}$ (b) $\frac{1}{\sqrt{2}}$ (c) $\frac{1}{2}$ (d) $\frac{1}{4}$

5 The opposite two graphs represent the displacement versus time curves for two bodies A, B moving in straight lines, so which of the following statements is correct?



(A) (B)

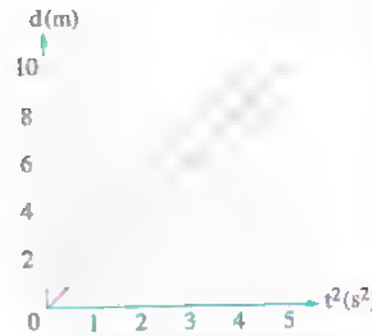
(a) Both bodies move with positive accelerations.

(b) Both bodies move with negative accelerations.

(c) Body (A) moves with a negative acceleration, while body (B) moves with a positive acceleration.

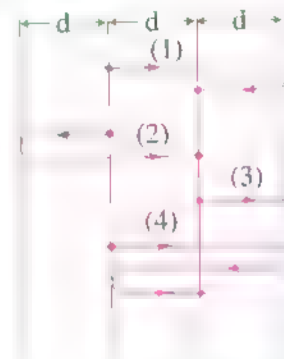
(d) Body (A) moves with a positive acceleration while body (B) moves with a negative acceleration.

6. The opposite graph represents the relation between displacement (d) and time squared (t^2) for a body moving from rest with a uniform acceleration, so its velocity after 10 s from the start of motion equals ....



(a) 10 m/s (b) 20 m/s
(c) 40 m/s (d) 60 m/s

7. The opposite figure illustrates the paths of motions of four bodies through the same time interval, so which of the following statements is correct?

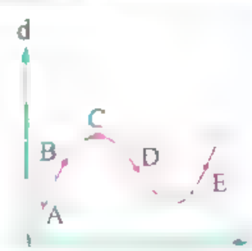


(a) All bodies have the same average speed.
The magnitude of the average velocity of body (4) is greater than that of all other bodies.
The magnitude of the average velocity of body (1) is equal to the average speed of the same body.
(d) All bodies have the same average velocity.

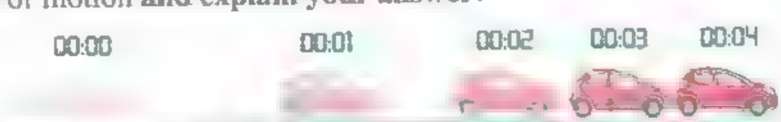
Answer the following questions (8 : 10) :

8. An arrow struck a tree with a velocity that was equal to 20 m/s at the instant of striking it. If the arrow penetrated the tree for a distance of 5 cm till it stopped, **calculate** the average acceleration with which the arrow moved through the tree.

9. The opposite graph represents the displacement versus time curve for a body, **so at which point** of A, B, C, D or E on the figure the body stops for an instant? **And why?**



10. The following figure illustrates the change of the position of a car moving in a straight line with a uniform acceleration, **determine** the direction of the acceleration relative to the direction of motion **and explain your answer**.



General Exams

All questions signed by * are answered in detail.

General Exam 1

Choose the correct answer (1 : 14) :

1 A ball of radius 1.7 cm, so its surface area equals ....

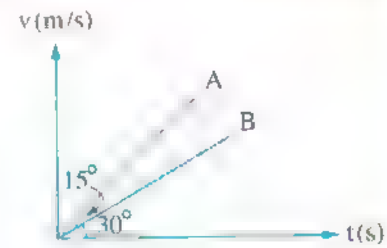
(Knowing that: The surface area of the ball = $4\pi r^2$)

(a) $2.1 \times 10^{-5}\ m^2$ (b) $9.1 \times 10^{-4}\ m^2$ (c) $3.6 \times 10^{-3}\ m^2$ (d) $0.11\ m^2$

2 Two balls A and B are projected vertically upwards from the same level such that the initial velocity of ball A was double that of ball B, so the maximum height reached by ball A is .... the maximum height reached by ball B.

(a) half   (b) double   (c) four times   (d) eight times

3 The opposite figure illustrates the relation between velocity (v) and time (t) for two objects A and B starting their motion from rest, therefore the ratio between the accelerations of the two objects $\left(\frac{a_A}{a_B}\right)$ equals ....



(a) $\frac{1}{\sqrt{2}}$ (b) $\frac{1}{2}$

(c) $\sqrt{3}$ (d) $\sqrt{2}$

4 If A = (2 ± 0.01) m and B = (80 ± 2) cm, then the value of (A + B) equals ....

(a) (80.2 ± 2.01) m   (b) (82 ± 2.01) cm   (c) (2.8 ± 2.01) cm   (d) (2.8 ± 0.03) m

5 ✳ Two objects started motion from rest with a uniform acceleration in a straight line for a distance d, if the time of motion of the first body is three times the time of motion of the second body, the ratio between the acceleration of the first body to the acceleration of the second body $\left(\frac{a_1}{a_2}\right)$ is ....

(a) $\frac{1}{1}$ (b) $\frac{1}{3}$ (c) $\frac{1}{9}$ (d) $\frac{1}{81}$

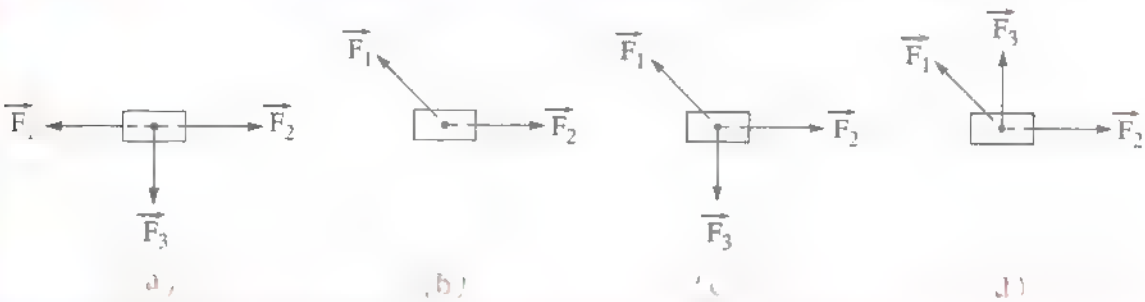
6 A ball is projected upwards with a velocity v_i in a direction that makes an angle θ with the horizontal, so when the ball reaches its maximum height, ...

	The resultant velocity of the ball	The acceleration of the ball
(a)	equals zero	equals zero
(b)	equals zero	doesn't equal zero
(c)	doesn't equal zero	equals zero
(d)	doesn't equal zero	doesn't equal zero

If the dimensional formula of both quantities x and y is LT^{-1} and the dimensional formula of quantity z is LT^{-2}, then the dimensional formula of the quantity k that verifies the equation: $x = y + zk$ is ....

(a) LT (b) LT^{-1} (c) L (d) T

The object that moves at a uniform velocity is represented by the figure ....



✳ Two students were racing in a straight line, if the average velocity of the first student was 4 m/s and the average velocity of the second student was 5 m/s where the second student reached the end of race before the first student by 5 seconds, then the distance of the race is ....

(a) 50 m (b) 75 m (c) 100 m (d) 150 m

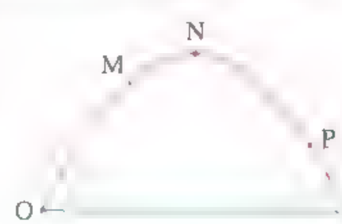
✳ An object started its motion from rest with a uniform acceleration in a straight line, if its velocity at the end of the fifth second was 5 m/s, its average velocity when it covers 50 m from the start of motion equals ....

(a) 5 m/s (b) 10 m/s (c) 15 m/s (d) 20 m/s

Which of the following mathematical operations on vectors are commutative?

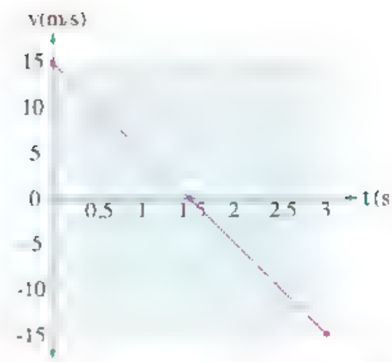
(a) Addition and subtraction. (b) Scalar product and cross product.
(c) Addition and dot product. (d) Subtraction and cross product.

A player projects a ball upwards from point O at an angle to the horizontal and the opposite figure illustrates the path of the ball, therefore the arrangement of the points M, N, P and O according to the speed of the ball is ....



(a) $N < O < M < P$ (b) $P < N < O < M$
(c) $N < M < P < O$ (d) $N < P < M < O$

The opposite graph illustrates the relation between the velocity of an object that is projected vertically upwards from the ground and the time, therefore the displacement of the body equals ....



(a) 0 (b) 5 m

(c) 10 m (d) 15 m

✳ In the opposite figure, if the resultant vector of the two vectors $\vec{A}$ and $\vec{B}$ is perpendicular to vector $\vec{B}$, the value of vector $\vec{A}$ is ....

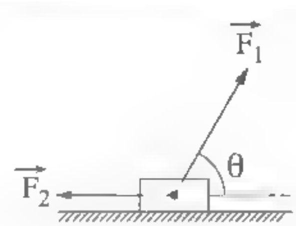
(a) $2\sqrt{2}$ units (b) $2\sqrt{3}$ units

(c) $3\sqrt{2}$ units (d) $3\sqrt{3}$ units

Answer the following questions (15, 16) :

When the speed and the time of motion of a car are measured, they are found to be (25 ± 0.5) m/s and (1 ± 0.01) s respectively, **so calculate** the distance covered by the car during this interval.

The opposite figure illustrates a box that moves horizontally with a uniform velocity on a frictionless surface under the effect of two forces, if we decreased the magnitude of the force $\vec{F}_2$ while the magnitude $\vec{F}_1$ is kept constant, **what** will be the change in the angle θ that keeps the box moving with uniform velocity?



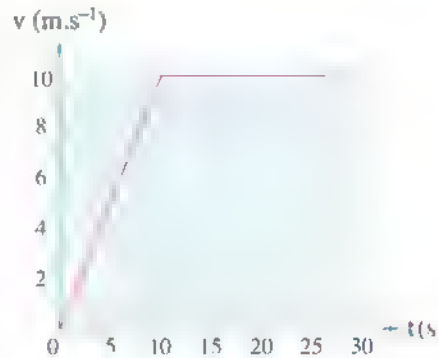
General Exam 2

Choose the correct answer (1 : 14) :

1. Two similar balls fell freely vertically from the top of a skyscraper such that the second ball fell 1 s later after the first ball, so the distance between the two balls during falling ....

(a) remains constant (b) increases (c) decreases (d) equals zero

2. The opposite graph represents the change in the velocity of a girl that runs in a straight racetrack with the time. If the girl covered a displacement of 200 m within 25 s, which of the following choices is correct at the time of 25 s?

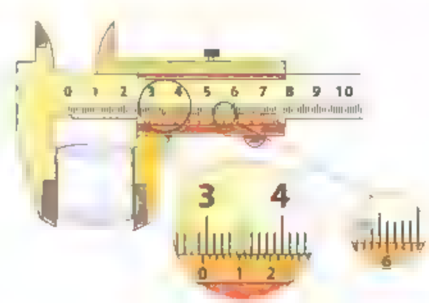


	The instantaneous velocity	The average velocity
(a)	8 m.s^{-1}	8 m.s^{-1}
(b)	8 m.s^{-1}	10 m.s^{-1}
(c)	10 m.s^{-1}	8 m.s^{-1}
(d)	10 m.s^{-1}	10 m.s^{-1}

3. If an object moved on a circle such that its displacement after half cycle becomes 2 π m, then the covered distance through the half cycle is ....

(a) π m (b) $\frac{\pi}{2}$ m (c) π^2 m (d) 2 π m

4. The opposite figure illustrates a vernier caliper used to measure the radius of a metallic cylinder. If the actual value of the diameter of the cylinder is 2.98 cm, so the relative error in that measurement equals ....

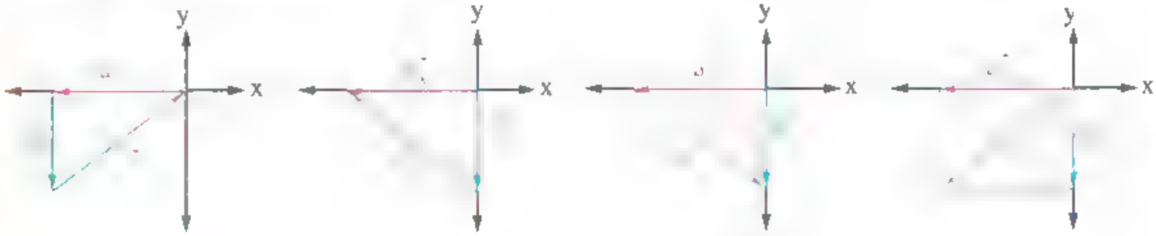


(a) $\frac{1}{148}$ (b) $\frac{1}{149}$

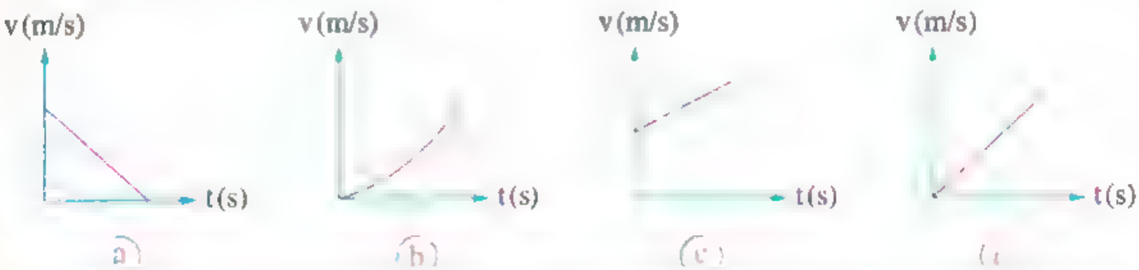
(c) $\frac{10}{173}$ (d) $\frac{1}{174}$

EXAM 2

Which of the following figures illustrates the resolution of vector $\vec{a}$ into its horizontal and vertical components correctly?



The (velocity-time) graph that describes the motion of a body that starts its motion with initial velocity (v_i) that doesn't equal zero and moves with uniform positive acceleration (a) during time (t) is ....



If x = 250 ms, y = 1500 µs, then the value of (x + y) equals ....

(a) 0.2515 s (b) 4 s (c) 250.15 s (d) 1750 s

A car is moving on a horizontal road with a uniform velocity of 10 m/s and it is affected by frictional forces of 1500 N, so the force by which the engine acts on the car is ....

(a) 150 N (b) 1500 N (c) 15000 N (d) 0

✱ An object is moving with a uniform acceleration according to the relation: $t = \frac{2\sqrt{d}}{3}$, where (d) is measured in meters and (t) is measured in seconds. So, its velocity after 2 s since it started its motion is ....

(a) $\frac{4}{9}$ m/s (b) $\frac{2}{3}$ m/s (c) 4 m/s (d) 9 m/s

A car moves in a straight line with a uniform acceleration where its velocity changed from 10 m/s to 90 km/h within 20 s, so the acceleration of the car and its type are ....

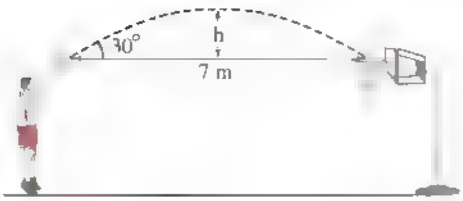
0.75 m/s^2, positive acceleration

4 m/s^2, positive acceleration

0.75 m/s^2, negative acceleration

4 m/s^2, negative acceleration

11 In a basket ball match, a player threw the ball as in the opposite figure, therefore the velocity (v) by which the player should throw the ball to reach the target basket and the maximum height (h) reached by the ball from the projection level approximately are .... , ... ($g = 10\ m/s^2$)



	v	h
a	9 m/s	1 m
b	9 m/s	2 m
c	81 m/s	1 m
d	81 m/s	2 m

12 If a body is projected at an angle of 75° to the horizontal, then it is projected once more with the same initial speed at an angle of 15° to the horizontal, therefore the horizontal range of the projectile ....

(a) increases
(b) decreases
(c) doesn't change
(d) cannot be determined, except by knowing the velocity of launching

13 By using the opposite table, which of the following equations may be correct?

(Knowing that : mass (m), radius (r))

Physical quantity	Its dimensional formula
Force (F)	$ML\,T^{-2}$
Velocity (v)	$M^0\,L\,T^{-1}$

(a) $F = mv^2r$ (b) $F = \frac{r}{mv^2}$ (c) $F = m\frac{v}{r}$ (d) $F = m\frac{v^2}{r}$

14 ✳ A car spent three hours during its trip in a straight line. If its average velocity during the first hour was 90 km/h and its average velocity during the last two hours was v and its average velocity during the whole trip was 75 km/h, therefore the value of v equals ....

(a) 2.5 km/h (b) 67.5 km/h (c) 135 km/h (d) 157.5 km/h

Answer the following questions (15, 16) :

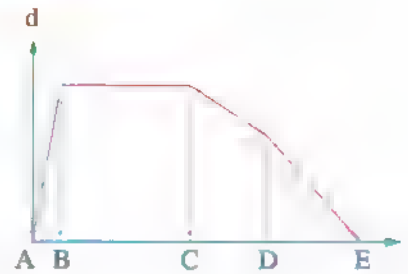
15. A vector $\vec{v}$ of 16 units makes an angle of 50° with the x-axis, **calculate** the vertical and the horizontal components for this vector.

16. **Explain** the decrease in the velocity of an object that is projected vertically upwards till it vanishes.

General Exam 3

Choose the correct answer (1 : 14) :

1. The opposite graph represents the relation between the displacement (d) and the time (t) for a car that moves in a straight line, so in which interval the velocity of the car is the greatest?



(a) Interval AB (b) Interval BC
(c) Interval CD (d) Interval DE

2. A man stands on the edge of a rocky cliff that overlooks a lake. He projects two identical balls A and B with the same speed. If A is projected vertically upwards and B is projected vertically downwards, so which of them will reach the water surface having higher velocity?

(a) The ball A (b) The ball B

(c) Both of them reach the water surface having the same velocity.

(d) No correct answer.

3. cm = ………… micrometer

(a) 10^2 (b) 10^4 (c) 10^6 (d) 10^8

4. When measuring the height of the fence of a garden from the ground by a meter tape it was found to be (3 ± 0.1) m, then ………… .

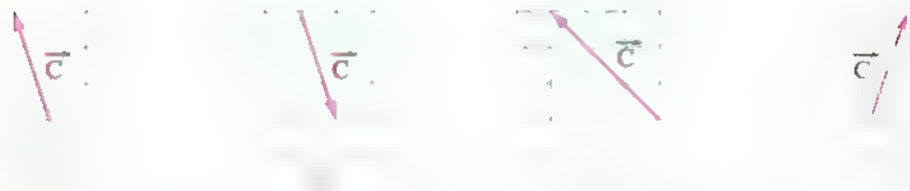
	Type of measurement	The relative error
a	direct	$\frac{1}{30}$
b	direct	$\frac{1}{10}$
c	indirect	$\frac{1}{30}$
d	indirect	$\frac{1}{10}$

5. When a horse pulls a cart, the force which causes the motion of the horse in the forward direction is ………… .

(a) the force by which the horse affects the cart
(b) the force by which the cart affects the horse
(c) the force by which the ground affects the cart
(d) the force by which the ground affects the horse

EXAM 3

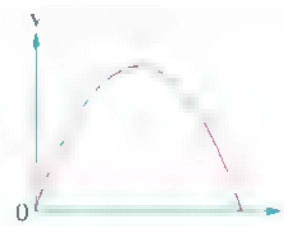
The opposite figure represents two vectors $\overrightarrow{X}, \overrightarrow{Y}$ of the same type, which of the following vectors represents the resultant vector $\overrightarrow{C}$, where $\overrightarrow{C} = \overrightarrow{X} + \overrightarrow{Y}$?

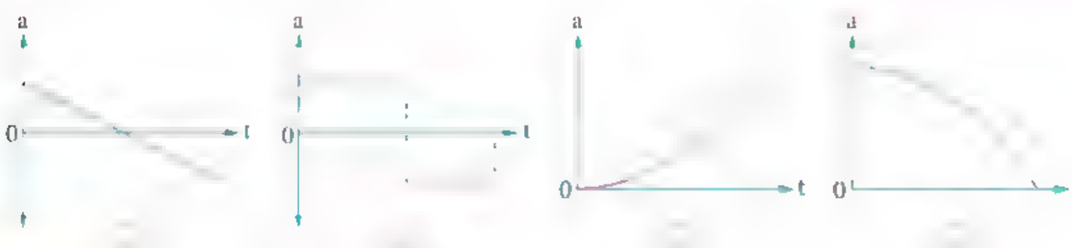


A body is projected with velocity (v) at an angle of 30° to the horizontal to have a horizontal range of 50 m, if the body is projected with the same velocity magnitude and at an angle of 60° to the horizontal, its horizontal range will be ...

(a) 25 m (b) 43 m (c) 50 m (d) 100 m

✳ The opposite graph represents the change in the velocity (v) of a body that moves in a straight line with the time (t), which of the following graphs represents the change in the acceleration (a) of this body with the time (t)?





If the dimensional formula of the quantity (x) is $L T^{-1}$ and the dimensional formula of the quantity (y) is ML^{-1}, so the dimensional formula of the quantity (z) that verifies the equation; $x = \sqrt{\frac{z}{y}}$ is ....

(a) MLT^{-1} (b) MLT^{-2} (c) ML^2T (d) MLT

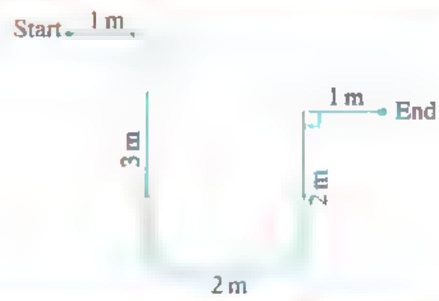
If a car covers 40 km towards the south during 1.5 h, then it changes its direction and moves 30 km towards the east during 0.5 h, so the average velocity of the car equals ______ .

(a) 5 km/h (b) 15 km/h (c) 25 km/h (d) 35 km/h

11 Two balls (A and B) were projected from the same point in the air, where ball (A) was projected at an angle to the horizontal greater than the angle by which ball (B) was projected. If the maximum height reached by the two balls is the same, which of the two balls has the larger time of flight?

(a) Ball (A).
(b) Ball (B).
(c) The two balls have the same time of flight.
(d) It cannot be determined, except by knowing the projection angles of the two balls.

12 The opposite figure represents the path of a moving body, therefore the value of the total displacement covered by the body equals ....



(a) 3.16 m
(b) 4.12 m
(c) 5 m
(d) 6.14 m

13 ✳ A railway worker stands 180 m away from the starting point of a train front whose length is 95 m which begins its motion from rest by a uniform acceleration, if the speed of the front of the train when it passes by the worker is 25 m/s, therefore the speed of the back of the train when it passes by the worker equals ....

(a) 10.51 m/s
(b) 21.42 m/s
(c) 30.91 m/s
(d) 43.44 m/s

14 ✳ A ball was projected vertically downwards with velocity (v) from a height of 4 m, then it reached the ground during a time that equals half the time taken by it when it was left to fall freely from the same height, therefore the value of (v) equals .... $(g = 10 \text{ m/s}^2)$

(a) 4.63 m/s
(b) 6.71 m/s
(c) 8.41 m/s
(d) 12.55 m/s

Answer the following questions (15, 16) :

15 **What happens to** a set of boxes that are placed on the top of a car and not being strapped when the car starts its motion suddenly and when it stops suddenly? **And why?**

16 The radius of a circle is measured and it was found to be (10.5 ± 0.2) m, **calculate** the area of the circle. (Knowing that: The area of the circle $= \pi r^2$)

General Exam 4

Choose the correct answer (1 : 14) :

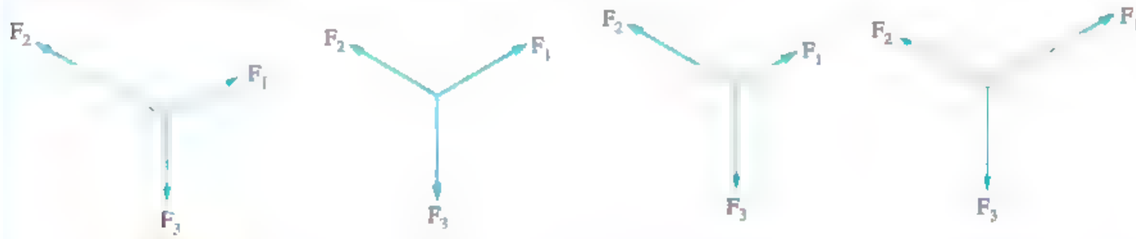
1. A body moves according to the relation; $d = 40\,t - 2\,t^2$, so its initial velocity and acceleration equal .... , ... respectively.

   (a) 40 m/s, -2 m/s^2 (b) 2 m/s, -40 m/s^2
   (c) 20 m/s, -1 m/s^2 (d) 40 m/s, -4 m/s^2

2. When two students measure the required time for a metallic ball to fall from the top of a building of height 5 m, the reading of the first student was 0.1 s and the reading of the second student was 10 s. Which reading is more logical?

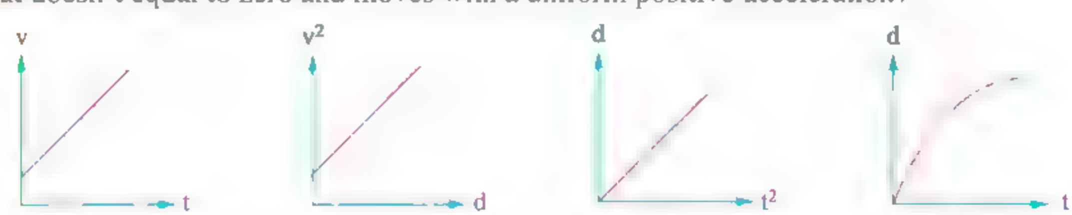
   (a) The two readings are logical.
   (b) The first reading is logical and the second reading is not logical.
   (c) The two readings are not logical.
   (d) The first reading is not logical and the second reading is logical.

3. A body moves with constant velocity under the effect of three forces $\vec{F}_1$, $\vec{F}_2$ and $\vec{F}_3$ that have equal angles between them, which of the following figures represents the forces that act on the body?



   (a) (b) (c) (d)

4. Which of the following figures represents a body that starts its motion with initial velocity that doesn't equal to zero and moves with a uniform positive acceleration?



   (1) (2) (3) (4)

   (a) Figure (1) only. (b) Figure (2) only.
   (c) Figures (1) and (2). (d) Figures (3) and (4).

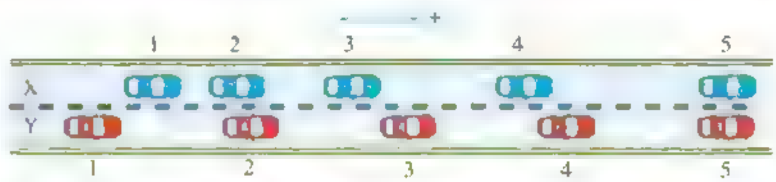
If the dimensional formula of the physical quantity (A) is M^2LT^{-2} and the dimensional formula of the physical quantity (B) is M^2LT^{-2}, so the dimensional formula of the quantity (4 A – 2 B) is ....

(a) $M^4L^2T^{-4}$
(b) $M^{-4}L^{-2}T^4$
(c) M^2LT^{-2}
(d) not have physical meaning

A car moves with a velocity of 30 m/s, its driver applies the brakes and the car is affected by a negative acceleration of 6 m/s^2, so the ratio of the velocity of the car after 1 s to its velocity after 2 s of applying the brakes is ....

(a) $\frac{1}{2}$
(b) $\frac{2}{3}$
(c) $\frac{3}{2}$
(d) $\frac{4}{3}$

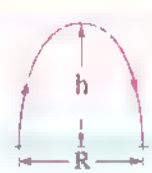
The next figure represents the positions of the two cars X and Y at consecutive intervals of time where the magnitude of each interval is 1 s and the direction of the two cars was to the right.



Which of the following statements correctly describe the motion of the two cars?

(a) The two cars move with non-uniform velocity.
(b) Car (X) moves with uniform velocity, while car (Y) moves with uniform acceleration.
(c) Car (X) moves with negative uniform acceleration, while car (Y) moves with uniform velocity.
(d) Car (X) moves with uniform positive acceleration, while car (Y) moves with uniform velocity.

✳ A body is projected upwards at an angle (θ) to the horizontal, if the horizontal range reached by the body equals the maximum vertical height reached by it, then the value of the angle (θ) is approximately ....



(a) 45°
(b) 60°
(c) 76°
(d) 90°

A group of students measure the velocity of a moving body, which of these measurements is more accurate?

(a) (350 ± 20) m/s
(b) (340 ± 15) m/s
(c) (335 ± 10) m/s
(d) (320 ± 10) m/s

10. Two trucks move in two parallel lines and in two opposite directions with the same speed which equals 90 km/h, if the distance between them is 8.5 km, therefore the two trucks meet after passing ....

(a) 0.05 s (b) 50 s (c) 120 s (d) 170 s

11. A ball was projected vertically upwards where it took 3 s to reach the maximum height, therefore the maximum height reached by the ball equals .... $(g = 10\ m/s^2)$

(a) 15 m (b) 30 m (c) 45 m (d) 80 m

12. ✱ Vector $\vec{A}$ has horizontal and vertical components of 3.2 units and 1.6 unit respectively and vector $\vec{B}$ has horizontal and vertical components of 0.5 unit and 4.5 units respectively, therefore the angle between the two vectors $\vec{A}$ and $\vec{B}$ equals .... respectively.

(a) 49° (b) 57° (c) 68° (d) 72°

13. If the radius of Earth is approximately equal to 6.4 Mm, then this is equivalent to ....

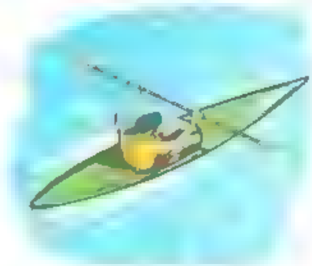
(a) 6.4×10^{-6} mm (b) 6.4×10^{6} μm (c) 6.4×10^{6} m (d) 6.4×10^{-9} Gm

14. ✱ The opposite figure shows a tennis player who hits a ball horizontally at a height of 2.5 m from the ground, therefore the velocity of projecting the ball (v) that makes it barely exceed the net that rises 0.9 m from the surface of the ground which is located away from the player at a horizontal distance of 15 m and the horizontal range of the ball (R), if it is projected by this velocity are .... $(g = 10\ m/s^2)$

	v	R
(a)	8.49 m/s	18.7 m
(b)	8.49 m/s	13.25 m
(c)	26.5 m/s	18.7 m
(d)	26.5 m/s	13.25 m

Answer the following questions (15, 16) :

15. ✱ The image illustrates a player in a boat race, **hence extract a pair** of forces in this situation that represents action and reaction.



16. A man moves in a straight line away from a building for a distance of 100 m, then he stops for 40 s and after that he completes his motion in the same direction to cover a distance of 0.5 km, **so what** is the position of the man away from the building?

General Exam 5

Choose the correct answer (1 : 14) :

1. ✳ A boat moves towards the east with velocity of 20 m/s, then it is affected by acceleration towards the west of 4 m/s^2, so its displacement after 15 s from the moment at which the boat starts to acquire the acceleration equals ………… .

   a) 350 m towards the east b) 300 m towards the west
   c) 750 m towards the east d) 150 m towards the west

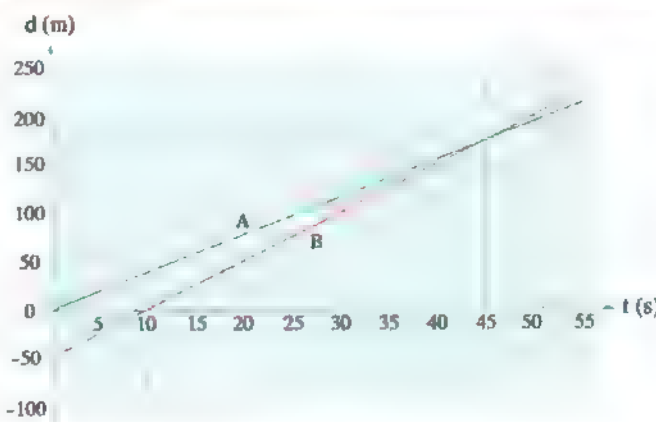
2. The scalar product of two vectors and the magnitude of their vector product become equal when the angle between the two vectors is ………… .

   a) 75° b) 60° c) 45° d) 30°

3. A bullet moves with a velocity of 220 m/s to hit a tree and penetrates it a distance of 4.33 cm until it stops, so the average acceleration of the bullet inside the tree is ………… .

   a) -5.59×10^3 m/s^2 b) -3.14×10^6 m/s^2
   c) -5.59×10^5 m/s^2 d) -2.54×10^3 m/s^2

4. The opposite graph represents the change of the positions of two runners A and B that move in a straight track in the same direction with the time. At the moment runner B passes runner A, ………… .



   a) the displacement and velocity of runner B are equal to displacement and the velocity of runner A
   b) the displacement and velocity of runner B are greater than the displacement and velocity of runner A
   c) the displacement and velocity of runner B are less than the displacement and velocity of runner A
   d) the displacement of runner B is greater than the displacement of runner A, while the velocity of runner B is equal to the velocity of runner A

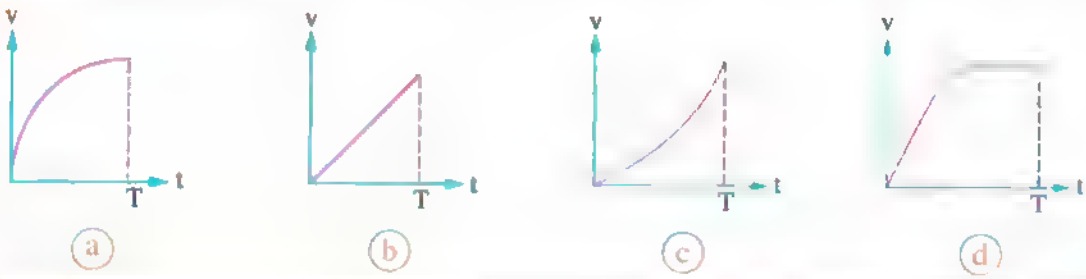
5. Which pair from the following quantities represent derived physical quantities?

   a) Plane angle and mass. b) Velocity and time.
   c) Distance and acceleration. d) Energy and density.

If the height of a student is (1.8 ± 0.05) m and the height of another student is (1.95 ± 0.05) m, so the second student is longer than the first student by ....

(a) (3.75 ± 0.05) m
(b) (3.75 ± 0.1) m
(c) (0.15 ± 0.1) m
(d) (0.15 ± 0.05) m

A body falls freely from the top of a building and reaches the ground after time (T), if the resistance of air is neglected, which of the following figures represents the change of its velocity with time?

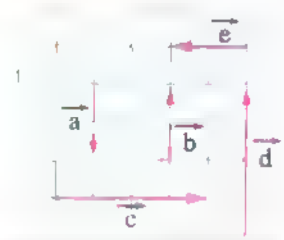


(a) (b) (c) (d)

A student carries a ball in her hand, if the force that acts on the ball by the Earth is the action force, so the reaction force is the force that acts on ....

(a) the Earth by the ball
the hand by the ball
the ball by the hand
the hand by the Earth

From the opposite diagram, which of the following relations is correct?

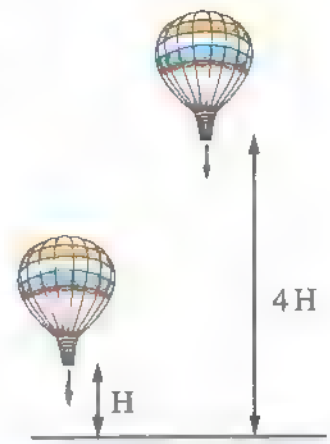


$\vec{a} = \vec{b}$
$\vec{a} = -\vec{b}$
(c) $\vec{e} = \frac{1}{2}\vec{c}$
(d) $\vec{a} = \frac{1}{2}\vec{d}$

A car starts its motion from rest with a uniform acceleration until its velocity reaches (v) then it continues its motion with uniform velocity for a while before the driver applies the brakes to decrease its velocity uniformly till it stops, which of the following graphs describes the motion of the car accurately?

(a) (b) (c) (d)

A box was dropped from a static balloon twice, firstly when the distance between the balloon and the ground was (H) then secondly when the distance was (4 H), therefore the ratio between the time taken by the box to reach the ground in the second case and the time taken by it in the first case respectively is ....



(a) $\frac{1}{1}$ (b) $\frac{4}{1}$

(c) $\frac{2}{1}$ (d) $\frac{\sqrt{2}}{1}$

When measuring the mass of a person, it was found to be 75.25 kg and by investigation it was found that the measurement was made by an error of 0.01 kg, therefore the actual mass of the person ranges between ....

(a) 75.24 kg, 75.25 kg (b) 75.25 kg, 75.26 kg

(c) 75.24 kg, 75.26 kg (d) 75.25 kg, 75.27 kg

In the next two figures, there's a child of weight 200 N sitting on a swing, where in figure (1) the ropes of the swing are vertical and in figure (2) the ropes of the swing are inclined, so in figure (2): What happens to the tension force (F) in each rope?

Figure (1)

Figure (2)

(a) Remains 100 N.

(b) Will be more than 100 N.

(c) Will be less than 100 N.

(d) The answer can't be determined.

14 Two cars were travelling on a desert road and after 5 s the two cars became adjacent at the third light pole as in the figure, if the distance between each two successive light poles is 70 m, so the ratio between the average velocities of the two cars A and B during the first five seconds shown in the two figures $\left(\frac{v_A}{v_B}\right)$ equals ....

6:31:00 6:31:05

(a) $\frac{1}{1}$ (b) $\frac{1}{2}$ (c) $\frac{2}{1}$ (d) $\frac{1}{4}$

Answer the following questions (15, 16) :

15 If two balls A and B rolled on the surface of smooth horizontal table with velocities v and 2 v respectively, then both of them fell from the surface of the table at the same time, **which of them** will hit the ground first? **And why**?

16 In an experiment to find the speed of sound (v) in air by using closed tubes, if you know that the relation between the frequency (f) of the sound wave in the tube and the length (ℓ) of the tube is $f = \frac{1}{4} v\ell^n$ by neglecting the effect of the radius of the tube, **find** the value of the constant (n) using the dimensional formula knowing that the frequency is measured in hertz ($Hz = s^{-1}$).

General Exam 6

Choose the correct answer (1 : 14) :

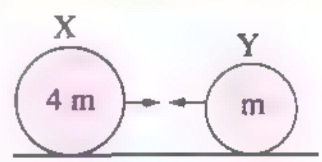
1. A body is moving according to the relation; $v_f = 2\,t$, where v_f is measured in m/s and t is measured in s. So, its displacement after 5 s from starting its motion equals ....

(a) 10 m (b) 15 m (c) 20 m (d) 25 m

2. When the density of a liquid is measured by a hydrometer, it is found to be $(10^3 \pm 1)$ kg/m^3. So, ...

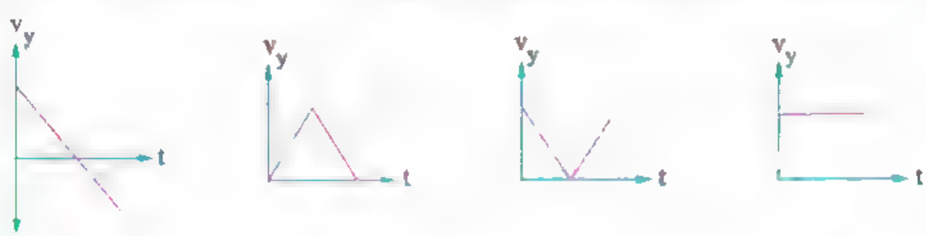
	The type of measurement is	The percentage of error in measurement is
a)	direct	0.1 %
b)	direct	1 %
c)	indirect	0.1 %
d)	indirect	1 %

3. The opposite figure shows the collision of the two bodies X and Y which have masses of m and 4 m respectively.
If body X acts on body Y during the collision by force $\vec{F}$, then body Y acts on the body X by force ....



(a) $\vec{F}$ (b) $\frac{1}{4}\vec{F}$ (c) $4\vec{F}$ (d) $-\vec{F}$

4. If a body is projected from the ground at angle θ to the horizontal, which graph of the following graphs represents the relation between the vertical component of the body velocity and the time till it reaches the ground again? (Neglect the air resistance)



(a) (b) (c) (d)

5. The motion of the Moon in its path around the Earth when it is observed during a whole night is considered .... motion in a ....

(a) periodic, straight line (b) vibrational, curved path
(c) translational, straight line (d) translational, curved path

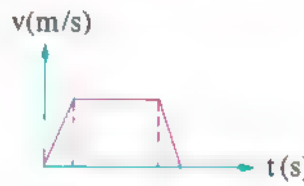
The most accurate tool for measuring the time taken by an object to fall from the top of a building is ....

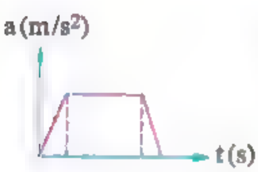
(a)

✳ A car moves from rest with uniform acceleration of 6 m/s^2, so the ratio between the distance moved by the car during the first second only and the distance moved by it during the third second only is ....

(a) $\frac{2}{3}$ (b) $\frac{1}{5}$ (c) $\frac{4}{9}$ (d) $\frac{9}{16}$

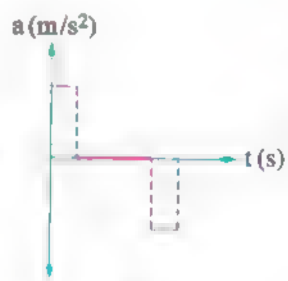
The opposite (velocity-time) graph describes the motion of a car, so the (acceleration-time) graph that represents the motion of the car is ....



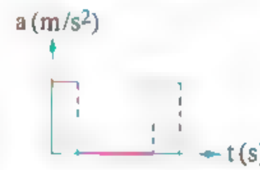


(a)

(b)



(c)



(d)

✳ A ball is projected horizontally with velocity v from the roof of a building and at the same time another ball is let to fall freely from the same height. Neglecting the air resistance, which of the following statements is right?

(a) The first ball reaches the ground first.

(b) The second ball reaches the ground first.

(c) The two balls reach the ground at the same time, where the velocity of the first ball is greater than that of the second ball.

(d) The two balls reach the ground at the same time, where the velocity of the second ball is greater than that of the first ball.

Which of the following mathematical expressions is correct?

ⓐ $\vec{A} \,.\, (\vec{B} \,.\, \vec{C})$

ⓑ $\vec{A} \,.\, (\vec{B} \wedge \vec{C})$

ⓒ $(\vec{A} + \vec{B}) + (\vec{B} \,.\, \vec{C})$

ⓓ $(\vec{A} \,.\, \vec{B}) + (\vec{B} \wedge \vec{C})$

A football player kicks a ball from the ground with velocity 18 m/s at an angle of 35° to the horizontal, therefore the time taken by the ball to reach the ground again equals .... approximately. ($g = 10\ m/s^2$)

ⓐ 1 s ⓑ 2 s ⓒ 3 s ⓓ 4 s

A rock falls freely from the top of a building of height 122.5 m. If the free fall acceleration equals $9.8\ m/s^2$, therefore the rock velocity before it reaches the ground by one second equals ....

ⓐ 25.3 m/s ⓑ 39.2 m/s ⓒ 49 m/s ⓓ 58 m/s

✳ A stone is projected vertically upwards with velocity 18 m/s from the ground, therefore the time required for the stone to reach a height of 11 m is ....
($g = 10\ m/s^2$)

	During its ascending	During its falling
ⓐ	0.52 s	1.42 s
ⓑ	0.52 s	2.82 s
ⓒ	0.78 s	1.42 s
ⓓ	0.78 s	2.82 s

Using the opposite figure, which of the following vectors are equal?

ⓐ The two vectors $\vec{A}$ and $\vec{E}$

ⓑ The two vectors $\vec{A}$ and $\vec{C}$

ⓒ The two vectors $\vec{G}$ and $\vec{F}$

ⓓ The two vectors $\vec{E}$ and $\vec{D}$

Answer the following questions (15, 16) :

A car covered a distance of 20 km in the west direction during 0.5 h, then it changes its direction to cover 20 km in the east direction during 0.5 h. **Calculate** the average speed of the car during its journey.

Assume that the displacement (d) of a body is related with time (t) as in the given relation: $d = ct^2$

Find the dimensional formula of c.

General Exam 7

Choose the correct answer (1 : 14) :

1. The body is in equilibrium when ....

(a) the resultant of the forces that acts on it equals zero

(b) it is static

(c) it is moving with constant velocity in a straight line

(d) all the previous

2. ✳ When a body falls freely, the ratio of its displacements after time of 1 s, 2 s and 3 s from the instant of fall is .... (Neglecting air resistance)

(a) 1 : 2 : 3 (b) 1 : 2 : 4 (c) 1 : 3 : 5 (d) 1 : 4 : 9

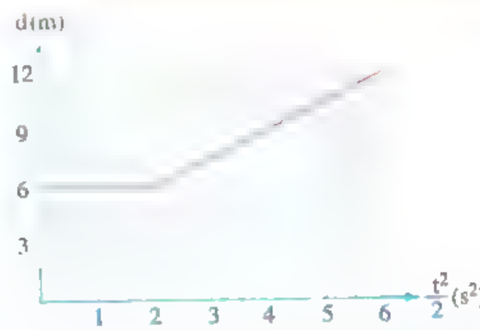
3. The opposite graph shows the $\left(d - \frac{t^2}{2}\right)$ relation for a car, so the acceleration of the car equals ....

(a) 6 m/s^2

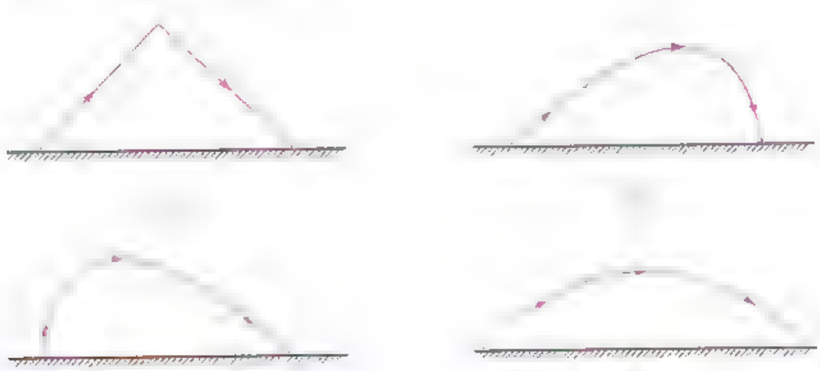
(b) 2 m/s^2

(c) 1.5 m/s^2

(d) 3 m/s^2



4. A boy projects a rock from the ground at an angle to the horizontal, which of the following diagrams represents the motion of the rock from the point of projection till it returns to the ground? (Neglecting air resistance)



A body moves in a straight line where its displacement (x) changes with time (t) according to this relation; $x = Bt + Ct^2$, then ....

	The dimensional formula of B is	The dimensional formula of C is
a	L	L^2
b	L	T^2
c	$L T^{-1}$	L^2
d	$L T^{-1}$	$L T^{-2}$

When the density of a cube was calculated, the percentage of error in measuring its mass was 2 % and the percentage of error in measuring its side length was 0.5 %, therefore the percentage of error in calculating its density equals ....

(Knowing that: Density = $\frac{\text{Mass}}{\text{Volume}}$)

(a) 1.3 % (b) 2.5 % (c) 3.5 % (d) 4 %

A racer accelerates his car in a straight line from rest to 180 km/h during 4 s, so it will cover a displacement of .... during 3 s.

(a) 86.45 m (b) 100 m (c) 112.5 m (d) 56.25 m

If the meter equals 3.281 feet, then the volume of a cube of side length 1.5 feet is

(a) 46×10^{-2} m^3 (b) 119.2 m^3 (c) 4.9 m^3 (d) 9.6×10^{-2} m^3

If the Earth acts on you when you are moving on it by an attraction force of 600 N, then your body acts on the Earth by an attraction force of ....

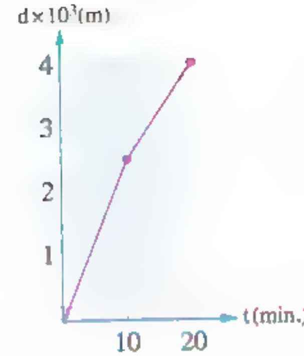
(a) zero (b) 300 N (c) 600 N (d) 1200 N

The most accurate measurement of the time of motion of a body from the following measurements is ....

(a) (3 ± 0.5) ms (b) (3.2 ± 0.5) ms

(c) (2.5 ± 0.025) ms (d) (2.5 ± 0.25) ms

1. The opposite graph shows the relation between the displacement covered by a runner and the time taken by him, therefore the average velocity of the runner during the time interval ....



	From t = 0 to t = 10 minutes	From t = 10 to t = 20 minutes
a	0.25 m/s	0.15 m/s
b	0.25 m/s	2.5 m/s
c	4.2 m/s	0.15 m/s
d	4.2 m/s	2.5 m/s

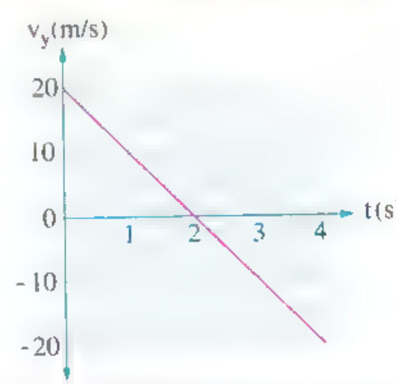
2. The scalar product of two vectors is maximum, when the angle between them equals ....

(a) 0° (b) 30° (c) 45° (d) 90°

3. A car is moving in a straight line by a velocity of 50 m/s, at a certain instant the driver applies the brakes, so the car velocity decreases uniformly till it reaches 30 m/s during a distance of 160 m, therefore the distance covered by the car from the instant of applying the brakes till it stops equals ....

(a) 200 m (b) 220 m (c) 250 m (d) 450 m

4. ✳ The opposite graph shows the change of the vertical component of the velocity of a body that is projected at an angle of 37° to the horizontal with the time, therefore the horizontal range of the body equals ....

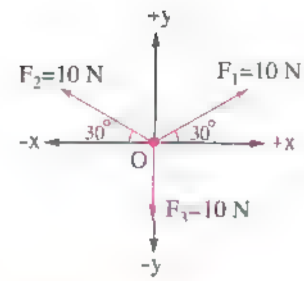


(a) 26.5 m (b) 58.4 m

(c) 80 m (d) 106.15 m

Answer the following questions (15, 16) :

15. The opposite figure shows three forces acting on a particle at point O, **find** the resultant of these forces.



16. **Can** the motion of a car be in the east direction, if the car is affected by an acceleration in the west direction at the same time? **Explain your answer.**

General Exam 8

Choose the correct answer (1 : 14) :

1. A bicycle is moving in a straight line with a positive uniform acceleration of $3\ m/s^2$, if it started motion with an initial velocity of 5 m/s, then after a displacement of 12.5 m its velocity becomes ....

   (a) 2 m/s   (b) 8 m/s   (c) 10 m/s   (d) 12 m/s

2. The dimensions of a metallic sheet is measured and found to be 22.3 mm, 4.35 mm and 12.7 mm, which of the following tools is used to measure them?

   (a) A ruler.   (b) The standard meter.
   (c) The meter tape.   (d) The vernier caliper.

3. A ball is projected horizontally with a velocity of 6 m/s from the edge of a horizontal table at a height of 0.8 m from the ground, so the horizontal distance between the impact point of the ball with the ground and the edge of the table equals .... ($g = 10\ m/s^2$)

   (a) 0.96 m   (b) 2.4 m   (c) 15 m   (d) 37 m

4. Which of the following figures represents the resultant vector $\vec{C}$ for the vectors $\vec{A}$ and $\vec{B}$?

(1)   (2)   (3)   (4)

   (a) Figures (1) and (2).   (b) Figures (3) and (4).
   (c) Figures (1) and (4).   (d) Figures (2) and (3).

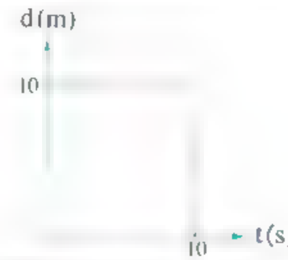
5. An object is moving in a straight line according to the relation; $v_f = \sqrt{49 + 6\,d}$
   If v_f is measured in m/s and d is measured in m, then the object is moving with acceleration of ....

   (a) $2\ m/s^2$ (b) $\sqrt{6}\ m/s^2$ (c) $3\ m/s^2$ (d) $6\ m/s^2$

A metallic ball of radius r is dropped into a tank of water, if its velocity in water was v and it is affected by a resistance force given by the relation: $F = Krv$ where K is constant, then the measuring unit of K is .... (Knowing that: $[F] = MLT^{-2}$)

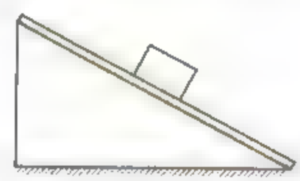
(a) $kg.m^2.s^{-1}$ (b) $kg.m^{-2}.s^{-2}$ (c) $kg.m^{-1}.s^{-1}$ (d) $kg.m.s^{-2}$

The opposite figure illustrates the displacement versus time graph for an object of mass 2 kg, so the resultant force acting on it is ....



(a) 100 N
(b) 200 N
102 N
0

The opposite figure illustrates an object that slides on an inclined smooth surface, which of the following statements describes the object motion correctly?



(a) Both velocity and acceleration increase.
The velocity increases, but the acceleration remains constant.
The velocity remains constant and the acceleration equals zero.
(d) Both the velocity and the acceleration are constant.

An object is projected vertically upwards, so its velocity at a vertical height of $\frac{h}{4}$ was 18 m/s where h is the maximum height reached by the object, then the value of h is .... ($g = 10\ m/s^2$)

(a) 28.7 m (b) 21.6 m (c) 15 m (d) 7.5 m

A bus was stopping at a traffic light when another bus collided with it suddenly from behind. Which of the following figures represents the movement of the passengers in the two buses at the moment of collision?

✻ A car is moving in a straight line with a velocity of 88 km/h behind a truck that is moving with a velocity of 75 km/h and at a distance of 110 m from the car, therefore the time required by the car to reach the truck equals ....

(a) 0.67 s (b) 8.46 s (c) 2.43 s (d) 30.46 s

✻ An object starts its motion from rest in a straight line with a uniform acceleration (a) and it makes a displacement (d) in time (t). If d = (200 ± 0.5) m and t = (20 ± 0.5) s, therefore the acceleration of the object equals ....

(a) $(1 \pm 0.0525)\ m/s^2$ (b) $(1 \pm 1)\ m/s^2$

(c) $(0.5 \pm 0.0525)\ m/s^2$ (d) $(0.5 \pm 1)\ m/s^2$

If x = (216 ± 6.48) cm, therefore the percentage of error in calculating (x^2) equals ....

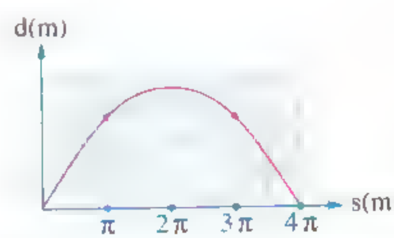
(a) 3 % (b) 6 % (c) 9 % (d) 12 %

✻ An object undergoes free falls from the top of a building. Therefore the ratio of the covered distance within the first second only, the covered distance within the second second only and the covered distance within the third second only is ....

(a) 1 : 2 : 4 (b) 1 : 3 : 5 (c) 1 : 2 : 3 (d) 1 : 2 : 5

Answer the following questions (15, 16) :

The opposite graph represents the relation between the displacement (d) which is made by an object that is moving in a circular path from a point on its path and the distance covered by it (s). **Calculate** the diameter of the circular path.



What are the velocity and acceleration of a projectile that is projected upwards with velocity v_i at an angle θ to the horizontal when it reaches its maximum height in terms of g, θ and v_i?

General Exam 9

Choose the correct answer (1 : 14) :

1. Two vectors $\vec{A}$ and $\vec{B}$ of the same type are equal in magnitude and perpendicular on each other, then the operation that makes their product ....

	Maximum	Zero
a	$\vec{A} \cdot \vec{B}$	$\vec{A} - \vec{B}$
b	$\vec{A} \cdot \vec{B}$	$\vec{A} \wedge \vec{B}$
c	$\vec{A} \wedge \vec{B}$	$\vec{A} - \vec{B}$
d	$\vec{A} \wedge \vec{B}$	$\vec{A} \cdot \vec{B}$

2. If an object is projected with a velocity v_i at an angle θ to the horizontal, then its horizontal range when it comes back to the same projection level can be calculated from the relation : ......

(a) $R = \frac{-v_i^2 \sin\theta \cos\theta}{2g}$

(b) $R = \frac{-v_i^2 \sin\theta \cos\theta}{g}$

(c) $R = \frac{-2 v_i \sin\theta \cos\theta}{g}$

(d) $R = \frac{-2 v_i^2 \sin\theta \cos\theta}{g}$

3. The projectiles motion is considered a motion in two dimensions, one is horizontal and the other is vertical, which of the following statements can describe the projectile's motion correctly?

(a) The velocity in the horizontal dimension is variable and the acceleration in the vertical dimension is variable.

(b) The velocity in the horizontal dimension is constant and the acceleration in the vertical dimension is variable.

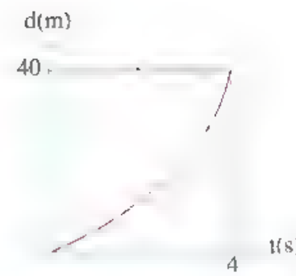
(c) The velocity in the horizontal dimension is variable and the acceleration in the vertical dimension is constant.

(d) The velocity in the horizontal dimension is constant and the acceleration in the vertical dimension is constant.

4. A man tried to push a box of mass 40 kg on a rough horizontal surface but he couldn't, so the net force acting on the box is .... $(g = 10\ m/s^2)$

(a) 0 (b) 40 N (c) 400 N (d) 4000 N

1. ✻ The opposite graph of displacement (d) versus time (t) illustrates the motion of an object that started its motion from rest with a uniform acceleration, so the acceleration of its motion is ....

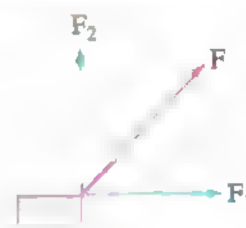


(a) $5\ m/s^2$ (b) $10\ m/s^2$
(c) $40\ m/s^2$ (d) $2.5\ m/s^2$

2. ✻ A train of length 100 m that is moving with an acceleration of $1\ m/s^2$ entered a straight tunnel of length 1.3 km with a velocity of 3 m/s, so the required time for the entire train to get out from the tunnel is ....

(a) 300 s (b) 78 s (c) 50 s (d) 20 s

3. In the opposite figure, an object is acted upon by two perpendicular forces $\vec{F}_1$ and $\vec{F}_2$, so their resultant force (F) is ....



(a) equal to $F_1 + F_2$ (b) less than $F_1 + F_2$
(c) greater than $F_1 + F_2$ (d) equal to $F_1 - F_2$

4. If the two physical quantities A and B have different dimensions, which of the following mathematical operations has a physical meaning?

(a) $A + B$ (b) $A - B$ (c) $A - \frac{A}{B}$ (d) AB

5. A man at rest started his motion in a straight line with uniform acceleration till his velocity reached 4 m/s within a time of 8 s, so the acceleration of his motion equals ....

(a) $0.5\ m/s^2$ (b) $1\ m/s^2$ (c) $2\ m/s^2$ (d) $4\ m/s^2$

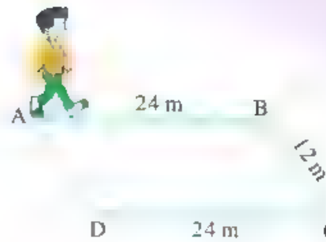
6. A student measured the dimensions of a garden of area $200\ m^2$, if the relative error in measuring this area was 0.05, then the absolute error for that measurement is ....

(a) $5\ m^2$ (b) $10\ m^2$ (c) $15\ m^2$ (d) $20\ m^2$

7. A ball was projected vertically upwards from the ground, then it passed in front of a person standing in a window at height of 28 m from the ground with a velocity of 13 m/s therefore the initial velocity of the ball equals .... approximately. $(g = 9.8\ m/s^2)$

(a) 15 m/s (b) 19 m/s (c) 22 m/s (d) 27 m/s

In the opposite figure a man moved from point A to point B within 10 s, then from point B to point C within 6 s, then from point C to point D within 14 s, therefore the magnitude of the average velocity by which he moved from point A to point D equals ....



(a) 0.4 m/s (b) 0.8 m/s (c) 1.5 m/s (d) 2 m/s

An object is projected horizontally from the top of a building and falls down at a distance d from the base of the building within a time t, if $d = (50 \pm 0.2)$ m and $t = (10 \pm 0.5)$ s, therefore the initial velocity by which the object is projected equals ....

(a) (5 ± 0.7) m/s (b) (5 ± 0.27) m/s (c) (2.5 ± 0.7) m/s (d) (2.5 ± 0.27) m/s

---

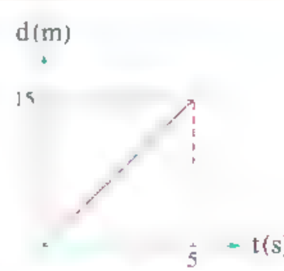
An object moves according to the relation; $v_f = 10\,t$, therefore its initial velocity and acceleration are equal to .... (Where: v_f is measured in m/s and t is measured in s)

	Initial velocity	Acceleration
(a)	0	5 m/s^2
(b)	0	10 m/s^2
(c)	10 m/s	5 m/s^2
(d)	10 m/s	10 m/s^2

Answer the following questions (15, 16) :

15. The light year is the distance covered by light within an Earth year with a speed of 2.998×10^8 m/s. **How many** meters in the light year?
(Where the Earth year = 365.25 days)

16. The opposite figure represents the (displacement-time) graph for a runner moving in a straight line with a uniform velocity. **Draw** the (displacement-time) graph for the runner if he moved with a uniform velocity double his previous velocity in the same direction within the same interval of time.



General Exam 10

Choose the correct answer (1 : 14) :

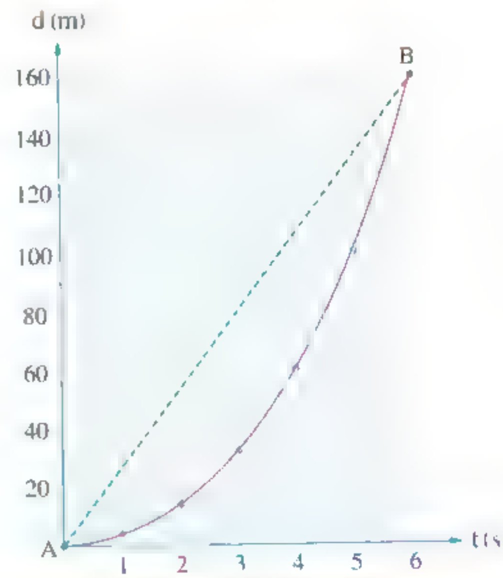
1. The time taken by a car that is moving in a straight line with acceleration of 2 m/s^2, to change its velocity by 10 m/s is ....

   (a) 0.5 s (b) 2 s (c) 5 s (d) 10 s

2. An object moved in a straight line for a distance of 100 m with a velocity of 10 m/s, then it moved in the same line for a distance of 200 m with a velocity of 5 m/s, so its average velocity through the whole trip equals ....

   (a) 7.5 m/s (b) 6 m/s (c) 8 m/s (d) 30 m/s

3. ✻ The opposite figure represents the (displacement-time) graph for an object that moves in a straight line within 6 seconds, so the slope of the dashed straight line AB is ....



   (a) greater than the average velocity of the object within 6 seconds

   (b) less than the average velocity of the object within 6 seconds

   (c) less than the instantaneous velocity of the object at the sixth second

   (d) equal to the instantaneous velocity of the object at the sixth second

4. The opposite figure illustrates three vectors $\vec{K}$, $\vec{L}$ and $\vec{N}$, which of the following equations is incorrect?

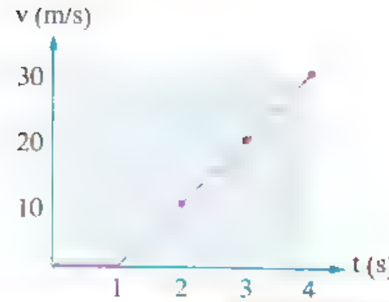
   (a) $\vec{K} + \vec{N} = 0$

   (b) $\vec{K} - \vec{N} = 2\,\vec{K}$

   (c) $\vec{K} = \vec{N}$

   (d) $\vec{K} + \vec{L} + \vec{N} = \vec{L}$

The opposite figure illustrates the (velocity-time) graph for an object, so its total displacement is ....

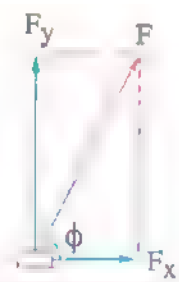


(a) 120 m
(b) 45 m
(c) 90 m
(d) 60 m

A car of mass 1000 kg moves with a uniform velocity of 12 m/s to the east, thus the resultant force acting on the car is ....

(a) 12000 N (b) 1200 N (c) 1012 N (d) 0

In the opposite figure, if $F_y = 2\,F_x$, then the value of ϕ equals ....



(a) 60°
(b) 37.67°
(c) 45°
(d) 63.43°

✳ If the maximum horizontal range for a projectile that is projected from the ground at an angle (θ) to the horizontal equals three times the maximum vertical height reached by it, therefore the value of the projection angle (θ) equals ....

(a) 15.53° (b) 33.13° (c) 53.13° (d) 64.16°

Two cars A and B are moving in a straight line where the velocity of A increases uniformly from 12 m/s to 18 m/s within $t_1 = 3$ s, while the velocity of B increases uniformly from 10 m/s to 25 m/s within $t_2 = 10$ s. Which of the following statements is correct?

(a) Displacement of A within t_1 < Displacement of B within t_2
(b) Acceleration of B is double the acceleration of A.
(c) Acceleration of A is double the acceleration of B.
(d) Average velocity of A within t_1 > Average velocity of B within t_2

The scalar product of the two vectors $\vec{A}$ and $\vec{B}$ equals 60 units and the magnitude of their vector product equals $20\sqrt{3}$ units, so the angle between the two vectors equals ....

(a) 15° (b) 30° (c) 45° (d) 75°

A tiger jumps horizontally from the top of a rock of height 6.5 m above the ground with a velocity of 3.5 m/s, therefore the horizontal range of the tiger's motion equals .... approximately. $(g = 10\ m/s^2)$

a) 2 m b) 4 m c) 5 m d) 8 m

If X = (5 ± 0.1) cm and Y = (7 ± 0.2) cm, therefore (Y – X) equals ....

a) (12 ± 0.3) cm b) (12 ± 0.1) cm c) (2 ± 0.3) cm d) (2 ± 0.1) cm

A box has fallen from a helicopter at a very large height from the ground during its rise vertically upwards with a uniform velocity of 8.76 m/s, therefore the distance between the box and the helicopter after a time of 3.05 s from the moment of its falling equals ....

(Knowing that: $g = 9.8\ m/s^2$, The air resistance is neglected)

a) 7.9 m b) 20.4 m c) 33.3 m d) 45.6 m

If the length of a living cell is 20 µm, so it is equivalent to .... in km.

a) 2×10^{-9} b) 2×10^{-8} c) 2×10^{-6} d) 2×10^{4}

Answer the following questions (15, 16) :

If the acceleration of an object equals zero, **does this mean** its velocity equals zero? **Give example to your answer.**

If the force of viscosity (F) that acts on a ball of radius r which falls in a liquid of viscosity coefficient η is given by the relation; $F = 6\pi\eta rv$ where v is the uniform velocity of the ball, **find** the measuring unit of the viscosity coefficient η.

(Knowing that: $[F] = MLT^{-2}$)

Notes

EL-MOASSER

By A Group Of Supervisors

PHYSICS

GUIDE ANSWERS

1st SEC. 2024

FIRST TERM

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Answers of Unit One

Chapter 1 Lesson One

First Multiple choice questions

1. ⓓ the time and the mass
2. ⓓ force - volume - density
3. ⓒ time in seconds
4. ⓑ 7.5 cm

The circumference of the coin (c)

$2c = 17 - 2$

$c = \frac{15}{2} =$ [illegible]

5. ⓑ
6. ⓓ
7. ⓒ 29.6 mm

The reading of the fixed scale (X): X = 29 mm

The reading of the vernier scale (x):

$x = 6 \times 0.1 = 0.6$ mm

The diameter of the cylinder (d):

$= X + x = 29 + 0.6 =$ [illegible]

8. ⓑ radian
9. ⓒ 1 nm ⟶ 1 μm ⟶ 1 mm ⟶ 1 cm
10. ⓑ 10^{-9}

$1 fs = 10^{-15}$ s

$= 10^{-15} \times 10^{6}$ μs

$=$ [illegible] μs

11. ⓓ all the previous
12. ⓓ 8.62 cm

Choice ⓐ: 86.2 mm = 86.2×10^{-3} m

$= 86.2 \times 10^{-3} \times 10^{6}$ μm

$= 862 \times 10^{2}$ μm

∴ Choice ⓐ is wrong

Choice ⓑ: 86.2 mm = 86.2×10^{-3} m

$= 86.2 \times 10^{-3} \times 10^{-3}$ km

$= 8.62 \times 10^{-5}$ km

∴ Choice ⓑ is wrong

Choice ⓒ: 86.2 mm = 86.2×10^{-3} m

$= 86.2 \times 10^{-3} \times 10^{-9}$ Gm

$= 0.862 \times 10^{-10}$ Gm

Choice ⓒ is wrong

Choice ⓓ: 86.2 mm = 86.2×10^{-3} m

$= 86.2 \times 10^{-3} \times 10^{2}$ cm

$=$ [illegible]

∴ Choice ⓓ is correct

13. ⓓ 5000
14. ⓐ 19×10^{6} nm

$l = (29 - 10)$ mm = 19 mm

$= 19 \times 10^{-3}$ m = $19 \times 10^{-3} \times 10^{9}$ nm

$= 19 \times 10^{6}$ nm

15. ⓒ 10.01 kg

$y = 10$ kg $= 10 \times 10^{3}$ g

$(10 + (10 \times 10^{-3}))$ g

$= 10.01 \times 10^{3}$ g $= 10.01$ kg

16. ⓐ 5×10^{9} kg

$m_{\text{[illegible]}} = 2.5 \times 2 \times 10^{6}$ ton

$= 5 \times 10^{6}$ ton $= 5 \times 10^{6} \times 10^{3}$ kg

$= 5 \times 10^{9}$ kg

17. ⓓ 100

The volume of one bottle (V_{ol}):

$V_{ol} = 10000$ cm³

$= 10000 \times 10^{-6}$ m³

$= 0.01$ m³

The number of bottles = $\frac{\text{The capacity of the tank}}{\text{The volume of one bottle}}$

$= \frac{1}{0.01} =$ [illegible] bottles

18. ⓐ 10 m/s

$= 36 \times \frac{5}{18} =$ [illegible]

19. ⓑ $ML^{-1}T^{-1}$
20. ⓒ x = 1, y = 3

The dimensional formula of density is $ML^{-3}T^{0}$

Its measuring unit is $kg.m^{-3}$ and it can be written kg/m^{3}.

$kg^{x}/m^{y} = kg/m^{3}$

21. ⓐ force

From the table, the dimensions of the quantities are as follows:

Force	Acceleration	Density	Velocity
MLT^{-2}	$M^{0}LT^{-2}$	$ML^{-3}T^{0}$	$M^{0}LT^{-1}$

and by comparing them to the given dimensional formula $M^{x}L^{x}T^{-2x}$

∴ The physical quantity may be the force

22. ⓐ has a dimensional formula of $ML^{2}T^{-2}$

23. ⓑ $ML^{0}T^{0}$

$\because x = yz$

$\left[\frac{x}{y}\right] = \frac{MLT^{-2}}{MLT}$ [illegible]

24. ⓑ the same dimensions

$[Ft] = MLT^{-2}T = MLT^{-1}$

$[mv] = MLT^{-1}$

The two quantities have the same dimensions

25. ⓒ has dimensions, has no dimensions

When two quantities of the same dimensional formula are added together, the resulting quantity will have the same dimensional formula of one of these quantities

∴ The relative speed has a dimensional formula

When dividing two quantities of the same dimensional formula, the resulting quantity will not have a dimensional formula

The relative density has no dimensional [illegible]

26. ⓒ LT^{-2}, LT^{-1}

$[x] = [At^{2}] + [Bt]$

$L = [A]T^{2} + [B]T$

The quantities that are added have the same dimensions

$\therefore [A]T^{2} \Rightarrow [A] = LT^{-2}$

$\therefore L = [B]T \Rightarrow [B] = LT^{-1}$

27. (i) ⓑ $v_f^{2} = v_i^{2} + 2ad$

In order for the equation to be possible, the dimensional formula for both sides of the equation must be equal

The dimensions of the L.H.S in all the choices

$[v_f^{2}] = L^{2}T^{-2}$

∴ The dimensions of the R.H.S must equal $L^{2}T^{-2}$

In choice ⓐ:

$[v_i] + [at^{2}] = LT^{-1} + LT^{-2}T^{2}$

$= LT^{-1} + L$ [illegible]

Choice ⓐ is wrong

In choice ⓑ:

$[v_i^{2}] + [2ad] = L^{2}T^{-2} + LT^{-2}L$

$= L^{2}T^{-2} + L^{2}T^{-2} = L^{2}T^{-2}$

Choice ⓑ is correct

In choice ⓒ:

$[v_i] + [2ad] = LT^{-1} + LT^{-2}L$

$= LT^{-1} + L^{2}T^{-2}$

Choice ⓒ is wrong

In choice ⓓ:

$[v_i^{2}] + [a^{2}d] = L^{2}T^{-2} + L^{2}T^{-4}L$

$= L^{2}T^{-2} + L^{3}T^{-4}$

Choice ⓓ is wrong

(ii) ⓓ $d = v_i t + \frac{1}{2}at^{2}$

In choice ⓐ:

The dimensional formula of the L.H.S

$[t] = T$

- The dimensional formula of the R.H.S.

$\left[\frac{v_f - v_i}{a}\right] = \frac{LT^{-1} - LT^{-1}}{LT^{-2}} = T$

Choice ⓐ is wrong

In choice ⓑ:

The dimensional formula of the L.H.S

$\left[\frac{d}{t}\right] = \frac{L}{T} = LT^{-1} = LT^{-1}$

- The dimensional formula of the R.H.S

$\left[\frac{1}{2}at\right] = LT^{-2}T = LT^{-1}$

Choice ⓑ is wrong

In choice ⓒ:

The dimensional formula of the L.H.S

$\left[\frac{v_f^{2} - v_i^{2}}{d}\right] = \frac{L^{2}T^{-2} - L^{2}T^{-2}}{L} = LT^{-2}$

- The dimensional formula of the R.H.S

$[a] = LT^{-2}$

Choice ⓒ is wrong

In choice ⓓ:

The dimensional formula of the L.H.S

$[d] = L$

- The dimensional formula of the R.H.S

$[v_i t] + [\frac{1}{2} a t] = LT^{-1}T + LT^{-2}T$

$= LT + LT^{-1}$

Choice ⓓ is correct

Second Essay questions

1 The physical quantity measured in $kg.m^{-3}$ is a derived quantity because it is defined by other fundamental quantities.

2 To arrange these masses, we will convert their measuring units to grams

(1) 15 g

(2) 0.032 kg = 0.032×10^{3} g = 32 g

(3) 2.7×10^{5} mg = $2.7 \times 10^{5} \times 10^{-3}$ g = 270 g

(4) 4.1×10^{-8} Gg = $4.1 \times 10^{-8} \times 10^{9}$ g = 41 g

(5) 2.7×10^{8} μg = $2.7 \times 10^{8} \times 10^{-6}$ g = 270 g

(3) = (5) > (4) > (2) > (1)

3 Because (platinum-iridium) alloy is rigid, does not react with the surrounding medium and it is slightly affected by temperature changes unlike other materials.

4 The statement is valid, because when the dimensions of both sides of the equation are different it means that the equation is physically impossible and that confirms that the rule is wrong. But when the dimensions of both sides of the equation are the same it does not mean for sure that the rule is correct, since the rule may include a numerical factors of a wrong value that makes the rule invalid.

5 The relation: $E = mc^2$

The dimensions of m = M

The dimensions of $c^2 = L^2T^{-2}$

The dimensions of $E = ML^2T^{-2}$

∴ The measuring unit of energy (E) is $kg.m^2/s^2$

6 (1) The dimensions of mass = M

The dimensions of acceleration = LT^{-2}

The dimensions of force (F) = MLT^{-2}

(2) The dimensions of force = MLT^{-2}

The dimensions of area = L^2

The dimensions of pressure (P) = $ML^{-1}T^{-2}$

(3) The dimensions of force (F) = MLT^{-2}

The dimensions of displacement = L

∴ The dimensions of work (W) = ML^2T^{-2}

7 (1) The relation: Work = $\frac{1}{2}mv^2$

The dimensional formula of the L.H.S:

$[W] = ML^2T^{-2}$

- The dimensional formula of the R.H.S

$[\frac{1}{2}mv^2] = M(LT^{-1})^2 = ML^2T^{-2}$

The dimensions of the two sides are equal

The relation may be correct

(2) The relation: $V_{ol} = \frac{4}{3}\pi r^3$

The dimensional formula of the L.H.S

$[V_{ol}] = L^3$

- The dimensional formula of the R.H.S

$[\frac{4}{3}\pi r^3] = L^3$

The dimensions of the two sides are equal

The relation may be correct

(3) The relation: $F = \frac{m}{V_{ol}}$

The dimensional formula of the L.H.S

$[F] = MLT^{-2}$

The dimensional formula of the R.H.S

$\frac{m}{V_{ol}} = ML^{-3}$

- The dimensions of the two sides are not equal

∴ The relation is wrong

(4) The relation: $A = \ell^3$

- The dimensional formula of the L.H.S

$[A] = L^2$

- The dimensional formula of the R.H.S

$[\ell^3] = L^3$

The dimensions of the two sides are not equal

The relation is wrong

(5) The relation: $v = a^2 t$

The dimensional formula of the L.H.S

$[v] = LT^{-1}$

The dimensional formula of the R.H.S

$[a^2 t] = L^2T^{-4}T = L^2T^{-3}$

The dimensions of the two sides are not equal

The relation is wrong

Answers of questions that measure high levels of thinking

1 ⓓ 0.677 g/cm^3

Density (ρ) = $\frac{\text{Mass (m)}}{\text{Volume (V)}}$

$\rho = \frac{m}{\frac{4}{3}\pi r^3} = \frac{5.68 \times 10^{26}}{\frac{4}{3} \times \frac{22}{7} \times (5.85 \times 10^7)^3}$

$= 677.04\ kg/m^3$ = [illegible]

$= 0.677\ g/cm^3$

2 ⓒ $25 \times 10^2\ kg/m^3$

$V_{marbles} = V_{displaced\ water} = 70 - 30 = 40\ cm^3$

$V_{marble} = \frac{40}{10} = 4\ cm^3$

[illegible] $= \frac{m_{marble}}{V_{marble}}$ = [illegible]

$= 25 \times 10^2\ kg/m^3$

3 ⓒ N.s

Choice ⓐ: ∵ N.m = $kg.m.s^{-2}.m = kg.m^2.s^{-2}$

∴ Its dimensional formula = ML^2T^{-2}

∴ Choice ⓐ is wrong

Choice ⓑ: ∵ $J.m^{-1} = kg.m^2.s^{-2}.m^{-1} = kg.m.s^{-2}$

Its dimensional formula = MLT^{-2}

Choice ⓑ is wrong

Choice ⓒ: ∵ N.s = $kg.m.s^{-2}.s = kg.m.s^{-1}$

∴ Its dimensional formula = MLT^{-1}

∴ Choice ⓒ is correct

Choice ⓓ: ∵ $J.s^{-1}$ = [illegible]

∴ dimensional formula = [illegible]

Choice ⓓ is wrong

4 ⓓ Joule

The measuring unit of pressure (P) is N/m^2 and the measuring unit of volume (V) is m^3

[illegible]

5 ⓒ $kg^{-1}.m^3.s^{-2}$

$F = G\frac{Mm}{r^2}$ ∴ $G = \frac{Fr^2}{Mm}$

$[G] = \frac{[F][r^2]}{[M][m]} = \frac{MLT^{-2}L^2}{MM} = M^{-1}L^3T^{-2}$

The measuring unit of G is $kg^{-1}.m^3.s^{-2}$

6 ⓑ N.s

The measuring unit of K.E is $kg.m^2.s^{-2}$

The dimensional formula of K.E is ML^2T^{-2}

K.E = [illegible]

P = [illegible] 2m (K.E)

[illegible]

P = $\sqrt{M^2L^2T^{-2}}$ = MLT^{-1}

The measuring unit of momentum is kg.m/s

The force is measured in newton (N) and its dimensional formula is MLT^{-2}

Newton (N) is equivalent to $kg.m.s^{-2}$

∴ The measuring unit of momentum is N.s

7 ⓒ $v = \sqrt{\frac{F_T}{\mu}}$

In order for the equation to be possible, the dimensional formula for both sides of the equation must be equal

The dimensional formula for the L.H.S in all the choices is [illegible]

The dimensional formula for R.H.S must be equal to [illegible]

In choice ⓐ

[illegible]

In choice ⓑ

[illegible]

[illegible]

Choice [illegible] is correct

In choice ⓓ

$[F_r \mu] = MLT^{-2}$ [illegible]

Choice ⓓ is wrong

ⓓ $x = yz + k$

$[x] = MLT^{-2}$, $[k] = MLT^{-2}$

$[y][z] = LT^{-2} M = MLT^{-2}$

While all choices ⓐ, ⓑ and ⓒ are wrong, where

- In choices ⓐ and ⓑ, we can not add physical quantities that don't have the same dimensional formula.
- In choice ⓒ, we find that:

The dimensions of the L.H.S ≠ The dimensions of the R.H.S

XY [illegible]

ZK [illegible]

XY = ZK

Chapter 1 Lesson Two

First Multiple choice questions

1. ⓐ mass of a body by a balance
2. ⓒ volume of a cube by measuring its length
3. [illegible] direct
4. ⓒ
5. [illegible]
6. ⓒ
7. ⓑ the relative error
8. (i) ⓒ 0.2 cm
   (ii) ⓓ 0.4 %
9. [illegible] 1.8 m
10. ⓑ 0.1 m, 0.01
11. ⓑ 55.18 m, 55.22 m

The real value is between [illegible]

$X + \Delta X = 55.2 + 0.02 = 55.22$ [illegible]

$X - \Delta X = 55.2 - 0.02 = 55.18$ [illegible]

12. ⓐ The room length [illegible]

To determine the measurement accuracy, we calculate the relative error in each measurement, the smaller the value of the relative error, the higher the measurement accuracy.

$r = \frac{\Delta x}{x}$

$r_A = \frac{0.05}{6} = 8.33 \times 10^{-3}$

$r = \frac{0.05}{4} = 12.5 \times 10^{-3}$

$r = \frac{0.05}{3.5} = 14.29 \times 10^{-3}$

$r = \frac{0.5}{30} = 16.67 \times 10^{-3}$

The correct choice is [illegible]

13. ⓒ

14. [illegible]

1 year = 365.25 × 24 × 60 × 60 = 31.5576 × 10^6 s

$r = \frac{|y_o - y|}{y_o}$

$= \frac{|(31.5576 \times 10^6) - (\pi \times 10^7)|}{31.5576 \times 10^6} = 0.004$

∴ The percentage of error [illegible]

15. ⓓ (1.05 ± 0.011) kg

To add two physical quantities, they should be identical in the measuring unit

	Gram (g)	Kilogram (kg)
x	[illegible] ± 10	[illegible] ± 0.01
y	[illegible]	0.05 ± 0.001
(x + y)	(1050 ± 11)	(1.05 ± 0.011)

The correct choice is ⓓ

16. ⓑ (3.33 ± 0.02) cm

[illegible]

= 5.68 − 2.35 = 3.33 cm

$\Delta l = \Delta l_A + \Delta l_B$

= 0.01 + 0.01 = 0.02 cm

[illegible]

17. [illegible] (40 ± 4.4) kg.m/s

The relative error in measuring the mass

[illegible]

The relative error in measuring the velocity

$r = \frac{\Delta v}{v} = \frac{0.04}{4} = 0.01$

The relative error in measuring the momentum:

[illegible]

- The real value of the momentum

$P_o = m_o v_o = 10 \times 4 = 40$ kg.m/s

- The absolute error in calculating the momentum.

$\Delta P = r_p P_o = 0.11 \times 40 = 4.4$ kg.m/s

$P = P_o \pm \Delta P$

= (40 ± 4.4) kg.m/s

18. ⓓ 0.0205, 16.4 kg/m³

$\rho = \frac{m}{V} = \frac{400}{0.5} = 800$ kg/m³

$r = \frac{\Delta m}{m} = \frac{0.2}{400} = 5 \times 10^{-4}$

$r = \frac{\Delta V}{V} = \frac{0.01}{0.5} = 0.02$

$r = r + r = 5 \times 10^{-4} + 0.02 =$ [illegible]

$\Delta \rho = \rho_o r = 800 \times 0.0205$ [illegible]

19. (i) [illegible] (15 ± 0.3) cm

$x_o + y_o = 5 + 10 = 15$ cm

$\Delta x + \Delta y = 0.1 + 0.2 = 0.3$ cm

[illegible]

(ii) ⓑ (20 ± 0.4) cm

$2x_o + y_o = (2 \times 5) + 10 = 20$ cm

$2\Delta x + \Delta y = 0.2 + 0.2 = 0.4$ cm

[illegible]

(iii) ⓒ (50 ± 2) cm²

$x_o y_o = 5 \times 10 = 50$ cm

[illegible] 0.02

[illegible] 0.02

$r = r_1 + r_2 = 0.02 + 0.02 = 0.04$

$r = \frac{\Delta(xy)}{x_o y_o}$

$\Delta(xy) = r x_o y_o = 0.04 \times 50 = 2$ cm²

$xy = (50 \pm 2)$ cm²

(iv) ⓓ (500 ± 30) cm³

[illegible] 500 [illegible]

[illegible]

[illegible] 0.02

$r = r_1 + r_2 + r_3 = 0.02 + 0.02 + 0.02 = 0.06$

$r = \frac{\Delta(xy^2)}{x_o y_o^2}$

$\Delta(xy^2) = r x_o y_o^2 = 0.06 \times 500 = 30$ cm³

$xy^2 = (500 \pm 30)$ cm³

20. (i) ⓒ $\frac{71}{552}$

$r = \frac{\Delta x}{x}$

$r_r = \frac{\Delta r}{r_o} = $ [illegible] $= \frac{2.4 - 2.3}{2.3} = \frac{1}{23}$

$= 2r + r_h$

$= 2 \times \frac{1}{23} + \frac{1}{24} = \frac{71}{552}$

(ii) ⓒ 10.26 cm³

$V = \pi r^2 h$

$= \frac{22}{7} \times (2.3)^2 \times 4.8 = 79.8$ cm³

$\Delta V = V r$

$= 79.8 \times \frac{71}{552} = 10.26$ cm³

21. ⓒ 0.03

$r_1 = r_2 = r_3 = 0.01$

$r = r_1 + r_2 + r_3 = 0.01 + 0.01 + 0.01 = 0.03$

22. [illegible]

[illegible]

where [illegible] is the side length of the cube

The relative error in measuring the volume

[illegible]

The relative error in measuring the density:

[illegible]

Second Essay questions

1. (1) - Do not look at the graduation scale at an oblique angle but look at it so that the line of vision is perpendicular to the scale.
   - The length of the graduating tool (ruler) must be suitable to the measuring length e.g. do not use the ruler to measure very small length or lengths larger than its scale.

   (2) It should be inside a closed glass box to avoid the effect of wind that causes error in measurement.

   The mass of the body should be small

(1) Because the absolute error can be determined from the relation [illegible] and the most important thing is estimating the error but not whether it is an increase or decrease in the real value.

(2) Because it is a ratio between two physical quantities having the same unit.

(3) Because it gives us the ratio of the error to the real quantity and not only the error.

Decreasing the percentage of error of the measurement.

To determine the accuracy of the measurements we will calculate the relative error of each measurement and it is clear that we error decreases the accuracy of measurement increases.

(a) $r =$ [illegible] $= 0.01$

(b) $r =$ [illegible] $= 0.01$

(c) $r =$ [illegible] $= 0.01$

(d) $r = \frac{[illegible]}{200} = 0.008$

(a) = (b) = (c) < (d)

Answers of questions that measure high levels of thinking

1. (i) [illegible]

$D = X + x = 2.5 +$ [illegible]

(ii) ⓑ 0.01 cm, 0.4 %

$\Delta D = D_u - D = 2.53 - 2.54 = 0.01$ cm

[illegible] $= 4 \times 10^{-3} = 0.4$ %

2. ⓐ $(1.61 \pm 0.17) \times 10^3$ kg/m³

$R = (6.5 \pm 0.2) \times 10^{-2} = (0.065 \pm 0.002)$ m

$V = \frac{4}{3}\pi R^3 = \frac{4}{3} \times \frac{22}{7} \times (0.065)^3$ [illegible]

$\rho = \frac{m}{V} = \frac{1.85}{[illegible]} =$ [illegible] $\times 10^3$ kg/m³

$r_V = 3 r_R = 3 \times \frac{\Delta R}{R_o} = 3 \times \frac{0.002}{0.065} = \frac{6}{65}$

$r_m = \frac{\Delta m}{m_o} = \frac{0.02}{1.85} = \frac{2}{185}$

$\Delta \rho = r_\rho \rho_o = \rho_o (r_m + r_V)$

$= 1.61 \times 10^3 \left(\frac{2}{185} + \frac{6}{65}\right) = 0.17 \times 10^3$ kg/m³

$\rho = \rho_o \pm \Delta\rho = (1.61 \pm 0.17) \times 10^3$ kg/m³

Answers of Test on Chapter 1

1. ⓓ
2. [illegible] 6.5 [illegible]
3. [illegible]
4. ⓐ force
5. [illegible] 180 ± 1.01 kg
6. ⓑ kg m/s
7. [illegible] 1000
8. ⓓ [illegible]
9. [illegible]
10. ⓓ not defined
11. ⓓ [illegible] cm
12. ⓓ [illegible]
13. [illegible]

The two added quantities must have equal dimensions.

The dimensional formula of x is L

The dimensional formula of v is L

14. ⓒ 5.6 mm

$X = 5$ mm

$x = 6 \times 0.1 = 0.6$ mm

$\ell = X + x = 5.6$ mm

15. Because it is not rigid enough and may be affected by the temperature

16. The sentence is wrong, where the relative error is better indicator for measurement accuracy than the absolute error, because the relative error gives us the ratio of the error to the real quantity and not only the error.

Chapter 2

First Multiple choice questions

1. ⓓ An iron piece mass of 60 kg
2. ⓓ the displacement of a moving body
3. ⓒ The velocity by which a body moves to east that is 2 m/s
4. ⓓ zero
5. (i) ⓐ 350 m (ii) ⓒ 150 m to east
6. (i) ⓐ 14 m

$s = 6 + 8 = 14$ m

(ii) ⓒ 10 m in the direction of $\overline{AC}$

From Pythagorean theorem

$d = \sqrt{(6)^2 + (8)^2} = 10$ m in the direction of $\overline{AC}$

(iii) ⓒ 28 m, 0

$s = 6 + 8 + 8 + 6 =$ [illegible]

$d = 0$

7. ⓒ

$d_{(a)} = 5 - 3 = 2$ m

$d_{(b)} = \sqrt{4^2 + 3^2} = 5$ m

$d_{(c)} = 7$ m

$d_{(d)} = 2$ m

∴ The correct choice is ⓒ

8. ⓐ 3000 m

The car is moving in a curved path.

The distance covered by the car is greater than its displacement

i.e. it is greater than 2 km (2000 m)

∴ The correct choice is ⓐ

9. ⓑ 50 cm, 130 cm

$d = 50$ cm

$s = 50 + (2 \times 30) + (2 \times 10) = 130$ cm

10. (i) ⓐ 10 m

$= 6 + 4 =$ [illegible]

(ii) ⓓ 2 m

$= 6 - 4 =$ [illegible]

11. ⓐ zero
12. ⓒ equal to
13. ⓒ $\pi\sqrt{2}$ cm

$l = \sqrt{r^2 + r^2}$

$= \sqrt{\pi^2 + \pi^2}$

[illegible]

14. ⓒ $\frac{\pi}{2}$

- Through $\frac{1}{2}$ cycle:

$s = \frac{1}{2}(2\pi r) = \pi r$

$d = 2r$

$\frac{s}{d} = \frac{\pi r}{2r} = \frac{\pi}{2}$

15. (i) ⓑ 12.57 m, 0

$s = 2\pi r = 2 \times \frac{22}{7} \times 2 = 12.57$ m

$d = 0$

(ii) ⓐ 22 m, $2\sqrt{2}$ m

$s = 1.75 \times 2\pi r = 1.75 \times 2 \times \frac{22}{7} \times 2 =$ [illegible]

$d = \sqrt{(2)^2 + (2)^2} = 2\sqrt{2}$ m

16. (i) ⓐ $100\sqrt{2}$ m in the direction of $\overline{AE}$

$d = AE = AC + CE$

$AC = \sqrt{(60)^2 + (60)^2} = 60\sqrt{2}$ m

$CE = \sqrt{(40)^2 + (40)^2} = 40\sqrt{2}$ m

$d = AC + CE = 60\sqrt{2} + 40\sqrt{2}$

$= 100\sqrt{2}$ m in the direction of $\overline{AE}$

(ii) ⓐ 200 m

$s = 60 + 60 + 40 + 40 = 200$ m

17. ⓒ 56 m

The distance between gate (1) and gate (2) represents quarter the circumference of the garden

$\frac{1}{4} \times 2\pi r = 44$, $\frac{1}{4} \times 2 \times \frac{22}{7} \times r = 44$

$r = 28$ m

The shortest distance between gate (1) and gate (3) represents the diameter of the garden

$d = 2r = 2 \times 28 = 56$ m

18. (i) ⓑ B

The displacement of a body that moves in a circular path equals the diameter of this path (2 r), when the body covers a distance that is equivalent to half the circumference of the circular path (distance = π r).

∴ The displacement of the body equals 2 r at point B

(ii) (d) 0

The body covers a distance of $2\pi r$ when it reaches point D (one complete revolution) which means it returns to its starting point

The displacement of the body at point D equals zero

19 (b) $\overline{A}$

20 (d) $-\frac{1}{2}\overline{d}$

$\overline{a} = 2$ units — Its direction is downwards

$\overline{b} = 2$ units — Its direction is upwards

$\overline{a} = -\overline{b}$

Choices (a) and (b) are wrong

$\overline{c} = 4$ units — Its direction is rightwards

$\therefore \overline{a} \perp \overline{c}$

Choice (c) is wrong

$\overline{d} = 4$ units — Its direction is upwards

$\overline{a} = -\frac{1}{2}\overline{d}$

21 (d)

22 (a) $\overline{K}$ $\overline{L}$

23 (d) $\overline{D}$

A = 5 units

B = 6 units

C = 5 units

D = 8 units

The correct choice is (d)

24 (b) equal to 1

25 (c)

26 (b)

27 $\overline{F}$ $\overline{E}$ $2\overline{F} + \overline{C}$

The right side in all choices is

$\overline{E} = 8$ units — Its direction is rightward

- The left side in choice (a)

$\overline{C} + \overline{B}$ $4 + 6 = 10$ units

The direction of the resultant is rightward

- The left side in choice (b)

$\overline{C} + 2\overline{F} = 4 + (2 \times 2) = 8$ units

The direction of the resultant is rightward

The left side in choice (c)

$3\overline{F} + \overline{D} = (3 \times 2)$ $4 = 2$ units

The direction of the resultant is rightward.

The left side in choice (d):

$\overline{A} + \overline{F} = \sqrt{A^2 + F^2} = \sqrt{(8)^2 + (2)^2} = 2\sqrt{17}$ units

The resultant makes an acute angle with the horizontal

The correct choice is (b)

28 (c) 15 N

$F = \sqrt{F_1^2 + F_2^2} = \sqrt{(9)^2 + (12)^2} = 15$ N

29 (a) 10 N, makes an angle of 36.87° with F_x

$F = \sqrt{F_x^2 + F_y^2} = \sqrt{(8)^2 + (6)^2}$

$= 10$ N

$\tan\theta = \frac{F_y}{F_x} = \frac{6}{8} = 0.75$

$\theta = 36.87°$

The resultant of the two forces makes an angle of 36.87° with F_x

30 (d)

$\Sigma F_x = F$ $2F$ [illegible] F

$\Sigma F_y = F$ [illegible] $F = \frac{1}{2}F$

In the choices:

Σ [illegible] $= F$

ΣF [illegible] $= \frac{1}{2}F$

$\therefore$ Choice (a) is wrong

$\Sigma (F_x)_b$ $2F$ $3F$ [illegible] F

$\Sigma (F_y)_b =$ [illegible]

$\therefore$ Choice (b) is wrong

$\Sigma (F_x)_c = 2F$

$\Sigma (F_y)_c$ [illegible]

Choice (c) is wrong

$\Sigma (F_x)_d = \frac{1}{2}F - \frac{3}{2}F = -F$

$\Sigma (F_y)_d$ [illegible]

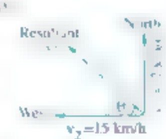
$\therefore$ Choice (d) is correct

31 (a) [illegible] km/h, 38.66° north of west direction

[illegible] $\sqrt{(12)^2 + 15^2}$ [illegible]

$\tan\theta =$ [illegible]

$\theta = 38.66°$



The net velocity makes an angle of 38.66° north of west

32 (d) 12

- The resultant of the two vectors (C) has the maximum value when the two vectors are in the same direction

$\overline{C} = \overline{A} + \overline{B} = 5 + 4 = 9$ units

- The resultant has the minimum value when the two vectors are in opposite directions

$\overline{C} = \overline{A} - \overline{B} = 5 - 4 = 1$ unit

$1 \le |\overline{C}| \le 9$

The resultant of the two vectors cannot be equal to 12 units.

The correct choice is (d)

33 (d) $\sqrt{5}$ F, 63.43°

ΣF_x [illegible]

$\Sigma F_y = 3F - F = 2F$

[illegible]

$\tan\theta = \frac{F_y}{F_x} = \frac{2F}{F} = 2$

[illegible]

34 (d)

35 (i) (d) $10\sqrt{2}$ N

$F_x = F\cos\theta = 20 \times \cos 45 = 10\sqrt{2}$ N

(ii) (c) $10\sqrt{2}$ N

$F_y = F\sin\theta = 20 \times \sin 45 = 10\sqrt{2}$ N

36 (i) (a) $5\sqrt{3}$ m

$d_x = d\cos\theta$

$= 10 \times \cos 30 = 5\sqrt{3}$ m

(ii) (c) 5 m

$d_y = d\sin\theta$

$= 10 \times \sin 30 = 5$ m

37 (b) 8.1 km, 19.9 km

$A_x = A\cos\theta$

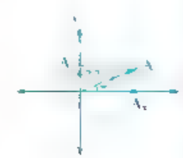
$= 21.5 \times \cos 22$

$= 19.9$ km

$A_y = A\sin\theta$

$= 21.5 \times \sin 22$

$= 8.1$ km



38 (i) (d) 6 N

$F = \sqrt{F_1^2 + F_2^2}$ $F_2 = \sqrt{F^2 - F_1^2}$

$F_2 = \sqrt{(10)^2 - (8)^2} = 6$ N

(ii) (a) 53.13°

$\tan\theta = \frac{F_1}{F_2} = \frac{8}{6}$

$\theta = 53.13°$

39 (a) $\theta < 45°$

40 (b) $F_y < F_x < F$

$F_x = F\cos\theta = F\cos 30 = \frac{\sqrt{3}}{2}F$

$F_y = F\sin\theta = F\sin 30 = \frac{1}{2}F$

$\therefore F > F_x > F_y$

41 (a) 4 N, 3 N

At $\theta = 0°$

$(\Sigma F)_1 = F_x + F_y = 7$ (1)

- At $\theta = 180°$

$(\Sigma F)_2 = F_x - F_y = 1$ (2)

By adding the two equations (1) and (2):

$2F_x = 8$

$F_x = 4$ N

By substituting in equation (1):

$F_y = 3$ N

The correct choice is (a)

42 (b) 100

43 (d) 8

44 (a) 180°

45 (c) 10 units

The two vectors are equal

The two vectors have the same magnitude and direction

$\overline{A} \cdot \overline{B} = AB\cos\theta$ [illegible] $\theta = 0$

$\overline{A} \cdot \overline{B} = A^2 = 25$ units

$A = B = 5$ units

[illegible]

46 (b) [illegible] units

$\overline{A} \cdot \overline{B} = AB\cos\theta$

$\cos\theta = \frac{\overline{A} \cdot \overline{B}}{AB} =$ [illegible]

$\theta = 60°$

$\vec{A} \wedge \vec{B} = AB \sin\theta\, \hat{n}$

$= 3 \times 5 \times \sin 60\, \hat{n} = 12.99\, \hat{n}$ units

The correct choice is ⓑ

19 ⓓ zero

$\because (\vec{A} \wedge \vec{B}) = -(\vec{B} \wedge \vec{A})$

$\therefore (\vec{A} \wedge \vec{B}) + (\vec{B} \wedge \vec{A}) = 0$

20 ⓒ 7.5

21 ⓑ less than 1

22 ⓒ $\overline{X} \cdot \overline{Y}$

- $(\overline{X} + \overline{Y})$ equals zero when the two vectors are equal in magnitude and opposite in directions.

$\because$ The two vectors are perpendicular

∴ Choice ⓐ is wrong.

- $(\overline{X} - \overline{Y})$ equals zero when the two vectors are equal in magnitude and in the same direction

∵ The two vectors are perpendicular

∴ Choice ⓑ is wrong

- $(\overline{X} \cdot \overline{Y})$ equals zero when the two vectors are perpendicular where

$\overline{X} \cdot \overline{Y} = XY \cos\theta = XY \cos 90 = 0$

- $(\overline{X} \wedge \overline{Y})$ equals zero when the two vectors are parallel

∵ The two vectors are perpendicular

Choice ⓓ is wrong

23 ⓑ into the page, into the page

Apply the right hand rule, by moving the fingers of the right hand from vector $\overline{V}$ to vector $\overline{B}$ through the smallest angle between them, then the thumb points to the direction of vector $\overline{F}$ and it will be perpendicular into the page in both cases.

Second Essay questions

1 According to the relation $\overline{A} \wedge \overline{B} = AB \sin\theta\, \hat{n}$, when $\theta = 90°$, $\overline{A} \wedge \overline{B} = AB\, \hat{n}$ (maximum value).

2 Because they have different directions.

3 (1) When they have the same magnitude and direction

(2) When the angle between the two vectors = 45°, since sin 45 = cos 45

4 No, because the magnitude of a vector is always positive while the negative sign of a vector indicates its direction only not its magnitude.

Answers of questions that measure high levels of thinking

1 (i) ⓓ – 10 m

$d = 20 - 30 = -10$ m

(ii) ⓐ 50 m

$s = 20 + 20 + 10 = 50$ m

2 ⓑ 1 m

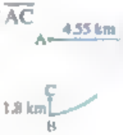
At the maximum displacement, the body covers half the circular path.

$s = \pi r$

$\pi = \pi r$

$r = 1$ m

3 (i) ⓒ 2.75 km in the direction of $\overline{AC}$



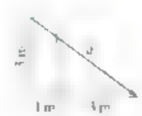
$= 4.55 - 1.8$

$= 2.75$ km in the direction of $\overline{AC}$

(ii) ⓐ 13.5 km

$s = 4.55 + \dfrac{2 \times \frac{22}{7} \times 4.55}{4} + 1.8 = 13.5$ km

4 ⓒ 7 m, 5 m



Distance

$s = 1 + 3 + 3 = 7$ m

Displacement

$d = \sqrt{(3)^2 + (4)^2} = 5$ m

5 ⓒ $2\sqrt{2}$ F

The resultant of the two forces $\overline{F}, \overline{F}$

$(\Sigma F)_1 = \sqrt{F^2 + F^2} = \sqrt{2}\, F$

$\tan\theta = \dfrac{F}{F} = 1$, $\theta = 45°$

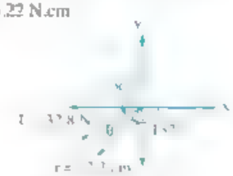
∴ The resultant $\Sigma \overline{F}_1$ in the same direction of the force $\sqrt{2}\, \overline{F}$.

$\Sigma F = (\Sigma F)_1 + \sqrt{2}\, F = \sqrt{2}\, F + \sqrt{2}\, F = 2\sqrt{2}\, F$

6 ⓒ

Because the two vectors $\vec{A}$ and $\vec{B}$ have equal magnitudes, so the resultant is between them and makes with them two equal angles.

7 ⓒ 533.22 N.cm



From the previous figure

$\theta = 360° - (132° + 90° + 118°) = 20°$

$\therefore \overline{F} \cdot \overline{r} = Fr \cos\theta = 32.8 \times 17.3 \times \cos 20$

$= 533.22$ N.cm

8 (i) ⓑ 60°

$|\vec{A} \wedge \vec{B}| = AB \sin\theta$ $A = 2B$

$3.5 = 2B^2 \sin\theta$

$\vec{A} \cdot \vec{B} = AB \cos\theta$

$4.5\sqrt{3} = 2B^2 \cos\theta$

By dividing equation (1) over equation (2)

$\tan\theta = \dfrac{3.5}{4.5\sqrt{3}}$

(ii) ⓒ 5.58 units

By substituting the value of θ in equation

$B = \sqrt{\dfrac{3.5}{2 \times \cos 60}} = 2.79$ units

$A = 2B = 2 \times 2.79 = 5.58$ units

9 ⓒ b cos θ = c cos ϕ

$\therefore \vec{a} \cdot \vec{b} = ab \cos\theta$

$\vec{a} \cdot \vec{c} = ac \cos\phi$

$\therefore b \cos\theta = c \cos\phi$

Answers of Test on Chapter 2

1 ⓐ greater than the magnitude of the vector product

2 ⓑ $-2\,\hat{e}$

3 ⓓ $78\sqrt{2}$ m

4 ⓒ 45°

5 ⓑ 6495.19 units, perpendicular out of the page

Answers of accumulative Test on Unit 1

6 ⓒ 5 N, makes angle 36.87° with the horizontal

7 ⓓ 2.12×10^{-2} m

8 ⓐ $F_x < F_y < F$

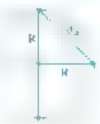
9 ⓑ 50 m, 90 m

10 ⓐ

11 ⓒ – 5 units

Their scalar product $= 2.5 \times 2 \times \cos 180° = -5$ units

12 ⓑ $\dfrac{\sqrt{2}}{2}$



At point A

The distance $= \dfrac{1}{2}\pi R$

∵ The body completes $\dfrac{1}{4}$ revolution.

The displacement at $A = \sqrt{R^2 + R^2}$

$= \sqrt{2}\, R$

At point B.

The distance $= \pi R$

The body completes $\dfrac{1}{2}$ revolution

The displacement at B = 2R

13 ⓓ $8\sqrt{2}$ cm

By ... the ... vector $\overline{B}$ ... vector $\overline{A}$ ...

$A = R = 8$ cm

14 ⓓ ...

15 Both (1) and (2) are wrong, because we can't add a scalar quantity and a vector quantity

16 The horizontal component of $\overline{C} = 4 - 2.5 = 1.5$ cm

The vertical component of $\overline{C} = -7.5 + 5$

$= -2.5$ cm

Answers of Accumulative Test on Unit 1

1 ⓓ 1 Gm = 10^{12} m

2 ⓑ the relative error

3 ⓓ 0

4 ⓓ ML^2T^{-2}

5 ⓒ small lengths

6 ⓐ $0°$

7 ⓓ between 1 N and 7 N

8 ⓐ $26.56°$

9 ⓒ $\vec{C} + \vec{A} = \vec{B}$

10 ⓑ direct, 0.1 m, 0.01

11 ⓑ 46.43×10^3

$d_{atom} = 0.26\ nm = 0.26 \times 10^{-9}\ m$

$d_{nucleus} = 5.6 \times 10^{-3}\ pm = 5.6 \times 10^{-3} \times 10^{-12}\ m$

$\frac{d_{atom}}{d_{nucleus}} = \frac{0.26 \times 10^{-9}}{5.6 \times 10^{-15}} = 46.43 \times 10^3$

12 ⓒ $\frac{\pi}{2\sqrt{2}}$

Distance $= \frac{2\pi r}{4}$

Displacement $= \sqrt{r^2 + r^2} = \sqrt{2}\, r$

$\frac{\text{Distance}}{\text{Displacement}} = \frac{\frac{1}{2}\pi r}{\sqrt{2}\, r} = \frac{\pi}{2\sqrt{2}}$

13 ⓐ $(71 \pm 3.4)\ 10^{-2}$ m/s

$r_x = \frac{\Delta x}{x_o} = [illegible] = 0.02$

$r_y = \frac{\Delta y}{y_o} = \frac{0.2}{[illegible]} = 0.028$

$r = r_x + r_y = 0.048$

$\Delta\left(\frac{x}{y}\right) = r \times \frac{5}{7} = 0.034$ m/s

$= (0.71 \pm 0.034)$ m/s $= (71 \pm 3[illegible]$

14 ⓓ 1.8 m

$r = 0.04$ [illegible] 45 m

$\Delta x = r \times x_o = 0.04 \times 45$ [illegible]

15 (a) Volume $= \pi r^2 \times h = \pi (5 \times 1[illegible]) \times 20 \times 10^{[illegible]}$

$= 1.571 \times 10^{[illegible]}\ m^3$

$1\ nm = 10^{-9}$ m

$1\ m = 10^{9}$ nm

$1\ m^3 = 10^{27}\ nm^3$

Volume $= 1.571 \times 10^{[illegible]} \times 10^{[illegible]}$ nm

$= 1.571 \times 10^{24}$ nm

(b) Mass = Density × Volume

$= 7800 \times 1.571 \times 10^{-3}$

$= 12.25$ kg

$\because 1\ kg = 10^6$ mg

Mass $= 12.25 \times 10^6$ mg

16 (a) $\vec{F_1}$ [illegible] $\vec{F_2}$

$\vec{F}_{net}$ makes 45° to $\vec{F}$

$\vec{F_1} \perp \vec{F_2}$

$F_{net} = \sqrt{F_1^2 + F_2^2} = \sqrt{2}\, F$

$F_1 = \frac{F_{net}}{\sqrt{2}} = \frac{35}{\sqrt{2}} = 24.74$ N

$F_2 = 24.74$ N

(b) $\vec{F_1} \cdot \vec{F_2} = F_1 F_2 \cos\theta$

$= 24.74 \times 24.74 \times \cos 90° = 0$

$\vec{F_1} \wedge \vec{F_2} = F_1 F_2 \sin\theta\ \vec{n}$

$= 24.74 \times 24.74 \times \sin 90°\ \vec{n}$

$= 612.06\ \vec{n}$

Answers of Unit Two

Chapter 1 Lesson One

First Multiple choice questions

1 ⓓ

2 [illegible]

3 ⓓ 22.9 m/s

$\frac{\Delta d}{\Delta t} = \frac{[illegible]}{[illegible] \times 60 \times 60}$

4 ⓒ 498.67 s

$t = \frac{d}{v} = \frac{1496 \times 10^5}{3 \times 10^5} = 498.67$ s

5 ⓓ 5 m/s

6 (i) Yes, by [illegible]

(ii) [illegible]

[illegible] $= \frac{\text{Total distance}}{\text{Total time}}$

$= \frac{6 \times 10^{[illegible]}}{25 \times 60} =$ [illegible]

7 ⓑ 5 [illegible] days

8 ⓓ

9 [illegible] $\frac{9}{2}$

Slope $= \frac{\Delta d}{\Delta t} = v$

$v_A = (\text{slope})_A = \frac{3d - 0}{t - 0} = \frac{3d}{t}$

$v_B = (\text{slope})_B = \frac{2d - 0}{3t - 0} = \frac{2d}{3t}$

10 [illegible] uniform velocity [illegible]

The graph that represents the relation between the displacement of the object and the time is a straight line inclined on the horizontal axis. The body moves with [illegible]

Slope $= \frac{\Delta d}{\Delta t}$

Slope $= \frac{60 - 0}{6 - 0} = \frac{60}{6}$ [illegible]

11 ⓑ the velocity of C > the velocity of B > the velocity of A

Slope $= \frac{\Delta d}{\Delta t} = v$

$(\text{slope})_C > (\text{slope})_B > (\text{slope})_A$

$\therefore v_C > v_B > v_A$

∴ The correct choice is ⓑ

12 (i) ⓓ 15 m/s

(ii) [illegible]

13 ⓓ [illegible]

14 ⓑ 29.9 km/s

When the Earth rotates around the Sun for one complete revolution, then

$s = 2\pi r$

Where r is the radius of the Earth's path around the Sun

$= \frac{2 \times \frac{22}{7} \times 1.5 \times 10^{[illegible]}}{365.25 \times 24 \times 60 \times 60}$

$= 29.9 \times 10^{[illegible]}$ m/s

15 (i) [illegible] 20 m

(ii) [illegible]

(iii) [illegible] 2 m/s

$\frac{\Delta d}{\Delta t} = \frac{10 - [illegible]}{5 - 0}$

16 ⓑ 8 [illegible] $\times 10^{[illegible]}$ m

$d = vt$

$\therefore d_{Alpha} = 3 \times 10^8 \times 15 \times 60 = 2.7 \times 10^{[illegible]}$ m

$d_{Beta} = 3 \times 10^8 \times 60 \times 60 = 1.08 \times 10^{12}$ m

The distance between the orbits of the two planets

$d = d_{Beta} - d_{Alpha}$

$= 1.08 \times 10^{[illegible]} - (2.7 \times 10^{[illegible]})$

$= 81 \times 10^{10}$ m

17 ⓑ 4 m/s

Average velocity = $\frac{\text{Total displacement}}{\text{Total time}}$

$\bar{v} = \frac{d}{t} = \frac{48}{12} = 4$ m/s

18 ⓐ greater than one

19 ⓓ 7.5 m/s, 4 m/s

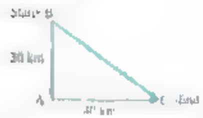
From t = 0 to t = 80 s:

$\bar{v} = \frac{d}{t} = \frac{600}{80} = 7.5$ m/s

Through the whole journey

$\bar{v} = \frac{600 - 200}{80 + 20} = 4$ m/s

20 (i) ⓒ 16.67 km/h



From Pythagorean theorem

$d = BC = \sqrt{(AB)^2 + (AC)^2}$

$= \sqrt{(30)^2 + (40)^2} = 50$ km

$\bar{v} = \frac{d}{t} = \frac{50}{0.5 + 2.5} = 16.67$ km/h

(ii) ⓑ 23.33 km/h

$v_{speed} = \frac{s_{total}}{t_{total}} = \frac{30 + 40}{0.5 + 2.5} = 23.33$ km/h

21 ⓐ before the second player by a time of 0.83 s

$t_1 = \frac{d_1}{v_1} = \frac{50}{3} = 16.67$ s

$t_2 = \frac{d_2}{v_2} = \frac{35}{2} = 17.5$ s

$\Delta t = t_2 - t_1 = 17.5 - 16.67 = 0.83$ s

The first player reaches the ball before the second player by a time of 0.83 s

22 (i) ⓓ 1 km/h in the south direction

d = [illegible] = 4 km

$\bar{v} = \frac{d}{t} = \frac{4}{4} = 1$ km/h in the south direction

(ii) ⓓ 5 km/h

[illegible]

$\bar{v}_{speed} = \frac{s}{t} = \frac{20}{4} = 5$ km/h

23 ⓐ Student A

24 ⓑ t_1, t_2

The slope of the (displacement-time) curve represents the velocity of the body.

The slope of the curve is negative through the interval between t_1, t_2

∴ The interval of time in which the direction of the body's velocity is negative is the interval between t_1, t_2

25 ⓒ $\sqrt{3}$

$= \frac{(\text{slope})_A}{(\text{slope})_B} = \frac{\tan 45}{\tan 30}$

26 (i) ⓐ positive and uniform

The relation between the girl's displacement and the time through the interval AB is represented graphically by a straight line which is inclined to the horizontal by an angle and its slope is positive

∴ The girl moves through the interval AB with positive uniform velocity

(ii) ⓓ equal to zero

The relation between the girl's displacement and the time through the interval BC is represented graphically by a straight line which is parallel to the time axis

The velocity of the girl through the interval BC = zero

(iii) ⓑ negative and uniform

The relation between the girl's displacement and the time through the interval CD is represented graphically by a straight line which is inclined to the horizontal by an angle and its slope is negative

The girl moves through the interval CD with negative uniform velocity

(iv) ⓓ

$v = \frac{\Delta d}{\Delta t}$ = slope

$(\text{slope})_{AB} > (\text{slope})_{CD}$

$v_{AB} > v_{CD}$, $v_{BC} = 0$

∴ The correct choice is (d)

27 (i) ① ⓐ 5 m/s

$\bar{v} = \frac{\Delta d}{\Delta t} = \frac{10 - 0}{2 - 0} = 5$ m/s

② ⓑ 1.25 m/s

$\bar{v} = \frac{\Delta d}{\Delta t} = \frac{5 - 0}{4 - 0} = 1.25$ m/s

③ ⓒ −3.67 m/s

$\bar{v} = \frac{-6 - 5}{7 - 4} = -3.67$ m/s

④ ⓓ 0

$\frac{0 - 0}{8 - 0}$

(ii) ① ⓓ 5 m/s

∵ The velocity from t = 0 to t = 2 s is uniform

The instantaneous velocity at t = 1 s equals the average velocity from t = 0 to t = 2 s which equals 5 m/s

② ⓐ −2.5 m/s

∵ The velocity from t = 2 s to t = 4 s is uniform

The instantaneous velocity at t = 3 s [illegible]

③ ⓒ 0

The slope of the line from t = 4 s to t = 5 s equals zero

∵ The instantaneous velocity at t = 4.5 s equals 0

④ ⓑ 6 m/s

∵ The velocity from t = 7 s to t = 8 s is uniform

∴ The instantaneous velocity at t = 7.5 s:

$\frac{0 - (-6)}{[illegible]}$

28 [illegible]

29 ⓓ $\frac{5}{3}$ v

[illegible]

$d_2 = v_2 t_2 = 2v \times 2t = 4vt$

[illegible]

30 ⓐ 69.57 km/h

$t_1 = [illegible] = 3.2$ h , $t_3 = 0.6$ h

$t_2 = \frac{d}{v} = \frac{320 - 240}{100} = 0.8$ h

$\bar{v} = \frac{320}{3.2 + 0.6 + 0.8} = 69.57$ km/h

31 (i) [illegible] 3.75 m/s

$s_{AB} = s_{BC} = \ell$

[illegible]

Average speed [illegible]

(ii) ⓓ 0

[illegible]

32 [illegible] 3.33 m/s

[illegible]

33 ⓐ 15 m/s

$d_1 = v_1 t_1 = 10 \times 60 = 600$ m

$d_2 = 20 \times 60 = 1200$ m

[illegible]

Second Essay questions

1 [illegible] which means that the body returns back [illegible]

2 $v_A = \frac{\Delta d_A}{\Delta t} = (\text{slope})_A = [illegible] = 2.5$ m/s

$v_B = \frac{\Delta d_B}{\Delta t_B} = (\text{slope})_B = \frac{[illegible]}{100 - 0} = 5$ m/s

Object (B) is faster because the slope of the straight line in the (displacement-time) graph of (B) is larger than (A).

3 (a) Object A is moving away from the building and object B is getting closer to the building.

(b) Object A is moving with uniform velocity because its motion is represented by a straight line

i.e. it covers equal displacements in equal time intervals.

Object B is moving with non-uniform velocity because its motion is represented by a curved line

i.e. [illegible]

4 (a) During the interval ab: The velocity of the car is uniform.

During the interval bc: The velocity of the car [illegible]

(b) d = [illegible] the curve

= [illegible]

5 (a) [illegible]

(b) [illegible] $= 0.125$ m/s

6 (a) The slope of the curve's tangent is positive at t = [illegible]

The velocity of the body is positive at t = [illegible]

(b) The slope of the curve's tangent vanishes at t = 2 s

The velocity of the body [illegible]

(c) The slope of the curve's tangent is negative at t = 3 s

The velocity of the body is negative at t = 3 s

Answers of questions that measure high levels of thinking

1 ⓒ 24 m/s

[illegible]

2 (b) Car A reaches [illegible] the race first.

From the graph: both cars have [illegible]

(D) at the same [illegible] which means the two cars reach the end of the race together.

∴ Statement (b) is wrong.

∴ The correct choice is (b).

3 ⓓ A precedes B after passing point x.

∵ The slope of the line representing the motion of boy (A) is greater than the slope of the line representing the motion of boy (B).

Slope = $\frac{\Delta d}{\Delta t}$ = v

The velocity of boy (A) is greater than the velocity of boy (B).

The two boys [illegible] at point (x)

[illegible]

4 (b) 45 km/h

[illegible]

5 [illegible] 75.94 m, 59.06 m

[illegible]

$v_A t + v_B t = 135$ m

$\therefore t = \frac{135}{v_A + v_B} = \frac{135}{6.75 + 5.25} = 11.25$ s

$d_A = v_A t = 6.75 \times 11.25 = 75.94$ m

$d_B = v_B t = 5.25 \times 11.25 = 59.06$ m

Chapter 1 Lesson Two

First Multiple choice questions

1 ⓑ $v_f = at$

2 ⓑ 8 m/s

3 [illegible]

4 [illegible] m/s

5 ⓓ 10 m/s, [illegible]

$v = \frac{\text{Total displacement}}{\text{Total time}}$

[illegible] $= 10$ m/s

$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i} = \frac{0 - 20}{10 - 0} = -2$ m/s²

6 ⓑ 2 s

$\bar{v} = \frac{v_i + v_f}{2}$

$1 = \frac{0 + v_f}{2}$

$v_f = 2$ m/s

$a = \frac{v_f - v_i}{t}$

$1 = \frac{2 - 0}{t}$

[illegible]

7 ⓑ initial velocity < its final velocity

8 ⓐ positive acceleration

9 ⓒ velocity decreases with time

10 ⓐ the velocity of the object increases

11 ⓒ

12 ⓑ negative non-uniform

13 ⓒ uniform acceleration of 5 m/s²

∵ The graph that represents the relation between the body's velocity and the time is a straight line which is inclined to the horizontal axis

∴ The body moves with uniform acceleration

∵ Slope $= \frac{\Delta v}{\Delta t} = a$

$\therefore a = \text{Slope} = \frac{30 - 0}{6 - 0} = 5$ m/s²

14 ⓑ

Slope $= \frac{\Delta v}{\Delta t} = a$

$a_{(a)} = \frac{8 - 0}{3 - 0} = 2.67$ m/s²

$a_{(b)} = \frac{60 - 0}{3 - 0} = 20$ m/s²

$a_{(c)} = \frac{3 - 0}{2 - 0} = 1.5$ m/s²

$a_{(d)} = \frac{15 - 0}{1 - 0} = 15$ m/s²

∴ The correct choice is ⓑ

15 ⓐ Body A

16 (i) ⓒ positive, zero, negative

(ii) ⓓ 5 m/s²

From A to B:

$a = \frac{\Delta v}{\Delta t} = \frac{20 - 0}{4 - 0} = \frac{20}{4} = 5$ m/s²

(iii) ⓐ − 5 m/s²

From C to D:

$a = \frac{\Delta v}{\Delta t} = \frac{0 - 20}{12 - 8} = \frac{-20}{4} = -5$ m/s²

(iv) ⓐ 80 m

$d = v\Delta t = 20 \times (8 - 4) = 80$ m

17 [illegible]

Slope $= \frac{\Delta v}{\Delta t} = a$

$\frac{(\text{slope})_A}{(\text{slope})_B} = \frac{\tan 60}{\tan 45}$ [illegible]

18 ⓓ

Car A:

Through the first 10 seconds, car A moves with uniform acceleration so the relation (v-t) is represented by a straight line which is inclined at an angle to the horizontal axis.

Through the next 10 seconds, the car moves with uniform velocity so the relation (v-t) is represented by a straight line which is parallel to the time axis.

Car B:

Through the first 10 seconds, car B moves with uniform velocity so the relation (v-t) is represented by a straight line which is parallel to the time axis and the value of the velocity is equal to the velocity of car A in the second interval.

Through the next 10 seconds the car moves with uniform acceleration which its value is equal to the value of uniform acceleration for car A in the first interval, so the relation (v-t) is represented by a straight line which is inclined to the horizontal axis and the value of its slope is equal to the value of the slope of the line that represents the motion of car A in the first interval.

∴ The correct choice is ⓓ

19 ⓒ The magnitude of the acceleration of A is larger than that of B.

The direction of the motion of the two bodies:

∵ The velocity of the two body through the whole motion is positive

The two bodies have the same direction of motion

The choice ⓐ is wrong

The acceleration of the two bodies:

$a = \text{Slope} = \frac{\Delta v}{\Delta t}$

$a_A = \frac{20 - [illegible]}{3 - 0} = [illegible]\ m/s^2$

$a_B = \frac{10 - 30}{6 - 0} = -3.33\ m/s^2$

$a_A \neq a_B$

a_A is positive, a_B is negative

∴ The choice ⓑ is wrong and [illegible]

The displacements of the two bodies

d = the area under the curve

$d_A = \frac{1}{2} \times 3 \times 20 [illegible]$

$d_B = (\frac{1}{2} \times 3 \times 1[illegible] + (20) \times 3) = 75\ m$

Choice ⓓ is wrong

20 ⓓ

The slope of the straight line in the (velocity-time) curve represents the acceleration of the body

- From t = 0 to t = 5 s, from t = 15 s to t = 20 s

a = Slope = 0

From t = 5 s to t = 15 s

$a = \text{Slope} = [illegible] = 1\ m/s^2$

[illegible]

21 ⓑ 20 m/s

The body starts its motion from rest

[illegible]

22 ⓒ $\frac{15}{16}\ m/s^2$

From the graph: The slope of the line that connects between the starting point and the end point represents the average velocity, then

$v = [illegible] = \frac{15}{4}\ m/s$

The body starts its motion from rest

$v_f = 2\bar{v} = at$

[illegible]

Second Essay questions

1 No, because the body that moves with uniform velocity has zero acceleration.

2 Yes, because if a car is moving to the north then it decelerates (starts to slow down), it will be moving at this time at an acceleration opposite to its direction of motion (to the south).

3 (1) is the acceleration.

(2) is the displacement.

(3) is the velocity.

4 [illegible]

Answers of questions that measure high levels of thinking

1 ⓑ negative, zero

- Through the interval AB

The relation (d-t) is represented by a curve

∴ The body moves with acceleration.

The slope of the curve decreases as time passes.

The velocity of the body decreases as time passes

The body moves with negative acceleration

- Through the interval BC

The relation (d-t) is represented by a straight line which is inclined at an angle to the horizontal axis

∴ The body moves with a uniform velocity.

i.e. zero acceleration

2 ⓒ The displacement of the car increases from t = 0 to t = 5 s

∴ The velocity of the car is positive throughout the represented interval in the graph

The car moves in one direction during the represented interval

The displacement of the car increases from [illegible]

3 [illegible] $3 < [illegible] < 2$

$a = \frac{\Delta v}{\Delta t}$ ∴ $\Delta v = a\,\Delta t$

∴ The magnitude of the change in the velocity of the body (Δv) = The area under the (acceleration-time) curve

∴ The correct arrangement is: $3 < 1 < 2$

4 ⓓ 120 s, 60 s, 120 s

In the interval AB

$\bar{v} = \frac{v_i + v_f}{2} = \frac{d}{t}$

[illegible]

In the interval BC

$v = \frac{d}{t}$

$t_2 = \frac{d}{v} = t$

- In the interval CD

[illegible]

$t = t_1 + t_2 + t_3$

$5 \times 60 = 2t + t + 2t = 5t$

[illegible]

Answers of Test on Chapter 1

1 ⓒ $\frac{at}{2}$

2 ⓓ moving in a direction opposite to the direction of motion at point P

3 ⓐ 7 m/s to the north

4 ⓓ A and B meet at (t = 3 s)

5 ⓑ 0.5 m/s

6 ⓓ XY

7 ⓓ A body is moving with constant velocity and variable acceleration

8 ⓑ 2 m/s²

9 ⓒ

10 ⓒ 240 m

11 ⓑ 40 km/h

Average speed = $\frac{\text{Total distance}}{\text{Total time}}$

$= \frac{20 + 20}{0.5 + 0.5}$

$= 40\ [illegible]$

12 ⓓ 7.5 m/s

$\bar{v}_{(0 \to 2\,s)} = \frac{v_i + v_f}{2}$

[illegible]

$\because a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{6 - 0}{2} = 3\ m/s^2$

The acceleration is constant

[illegible]

$v_f = 15\ m/s$

$\bar{v}_{(0 \to 5\,s)} = \frac{v_i + v_f}{2} = \frac{0 + 15}{2} = 7.5\ m/s$

13 ⓓ

[illegible]

Zero acceleration

14 ⓑ 1.5 v

$\bar{v} = \frac{\text{Total displacement}}{\text{Total time}} = \frac{d_1 + d_2}{t_1 + t_2}$

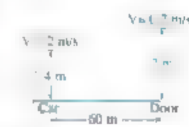
$t_1 = \frac{d_1}{v} = \frac{d}{v}$ $t_2 = \frac{d_2}{2v} = \frac{2d}{2v} = \frac{d}{v}$

$t_1 = t_2 = t = \frac{d}{v}$

[illegible]

15 The time needed for the car to pass the door = t_{car}

$t_{car} = \frac{d}{v_{car}} = \frac{60}{12} = 5\ s$



The distance moved by the door at the moment when the car reaches the door = d_{door}

$d_{door} = v_{door} \times t_{car} = 0.2 \times 5 = 1\ m$

The height of the car is 1.4 m, so the thief will not succeed to escape because the door will be 1 m away from the ground.

16 When the body moves at a uniform (constant) velocity

Chapter 2 Lesson One

First Multiple choice questions

1 ⓓ 25 s

$v_f = v_i + at$

2 ⓐ 30 m/s

$v_f = v_i + at$

3 ⓑ 8.2 s

$v_i = 72 \times \frac{5}{18} = 20$ m/s

$v_f = 13 \times \frac{5}{18} = 3.6$ m/s

$v_f = v_i + at$

$t = \frac{v_f - v_i}{a} = \frac{3.6 - 20}{-2} = 8.2$ s

4 ⓑ 4 m/s²

$v_f = v_i + at$

$a^2 = 16$

5 ⓒ

6 ⓑ 200 m

7 ⓓ

8 ⓓ 0

Displacement = The area under the (velocity - time) curve

$\therefore d = \left(\frac{1}{2} \times 10 \times 6\right) + \left(\frac{1}{2} \times 10 \times (-6)\right) = 0$

9 ⓐ 128 m

$d_1 = vt_1 = 4 \times 8 = 32$ m

$d_2 = v_i t_2 + \frac{1}{2} a t_2^2$

$= (4 \times 6) + \left(\frac{1}{2} \times 4 \times (6)^2\right) = 96$ m

$d = d_1 + d_2 = 32 + 96 = 128$ m

10 ⓒ 4 d

$d = v_i t + \frac{1}{2} a t^2$ $\quad v_i = 0$

$d = \frac{1}{2} a t^2$

$d \propto t^2$

11 ⓒ $\frac{1}{4}$

$d = v_i t + \frac{1}{2} a t^2$ $\quad v_i = 0$

$d = \frac{1}{2} a t^2$

The two bodies have covered the same displacement (d)

$a \propto \frac{1}{t^2}$

12 ⓒ 2 m/s²

$d = v_i t + \frac{1}{2} a t^2$ $\quad v_i = 0$

$d_1 = \frac{1}{2} a t^2$

$d_1 + d_2 = 300$

$\frac{1}{2} a t^2 + a t^2 = 300$

$1.5\, a t^2 = 300$

$1.5\, a \times (10)^2 = 300$

$a = 2$ m/s²

13 ⓑ 58.81 s

The train leaves the tunnel entirely when it covers a distance that equal to the sum of the tunnel length and the train length.

$\therefore d = 1$ km $+ 100$ m $= 1100$ m

$d = v_i t + \frac{1}{2} a t^2$

$\therefore 1100 = 4t + \left(\frac{1}{2} \times 0.5 \times t^2\right)$

$\frac{1}{4} t^2 + 4t - 1100 = 0$

By using the calculator

$t = 58.81$ s

The time required for the train to leave the tunnel entirely is 58.81 s.

14 ⓑ 49 m

15 ⓓ 5×10^3 m/s²

$v_f^2 - v_i^2 = 2ad$

$a = \frac{v_f^2 - v_i^2}{2d} = \frac{0 - (100)^2}{2 \times 1} = -5 \times 10^3$ m/s²

16 ⓒ 48.9 m

- When the car moves with velocity 56 km/h:

When the car moves with velocity 113 km/h

Another Solution:

$v_f^2 - v_i^2 = 2ad$ $\quad v_f = 0$

17 ⓑ

$v_f^2 = v_i^2 + 2ad$ $\quad v_i = 0$

$v_f^2 = 2ad$

$\because$ The car gets accelerating uniformly

$v_f^2 \propto d$

18 ⓑ $10\sqrt{3}$ m/s

Slope $= \frac{\Delta v}{\Delta t} = a$

$\therefore v_f^2 = 0 + (2 \times \frac{3}{2} \times 100)$

$v_f = 10\sqrt{3}$ m/s

19 ⓑ 40 m/s

$10 = \frac{20}{t}$ $\quad t = 2$ s

$d = v_i t + \frac{1}{2} a t^2$ $\quad v_i = 0$

$a = 10$ m/s²

$v_f = v_i + at$

$= 0 + (10 \times 8) = 80$ m/s

$\bar{v} = \frac{v_f + v_i}{2} = \frac{80 + 0}{2} = 40$ m/s

20 ⓓ 4.98×10^{-9} s

$\because v_f^2 - v_i^2 = 2ad$

$a = \frac{v_f^2 - v_i^2}{2d}$

$= 1.2 \times 10^{15}$ m/s²

$v_f = v_i + at$

Another Solution:

$= \frac{2 \times 1.5 \times 10^{-2}}{6 \times 10^6 + (2 \times 10^4)} = 4.98 \times 10^{-9}$ s

21 (i)

(ii) ⓑ 100 m

$= 200 - 100 = 100$ m

(iii) ⓒ 10 m/s

$\bar{v} = \frac{v_i + v_f}{2} = \frac{20 + 0}{2} = 10$ m/s

(i) ⓑ 150 m

$d = v_i t + \frac{1}{2} at^2$

$= (40 \times 5) + \left(\frac{1}{2} \times (-4) \times (5)^2\right) = 150$ m

(ii) ⓓ 10 s

$v_f = v_i + at$

$0 = 40 + (-4) t$

[illegible]

ⓒ The driver would pass the traffic light with 23 m.

$v = \frac{80 \times 10^3}{60 \times 60} = 22.22$ m/s

$v_f^2 - v_i^2 = 2ad$

$0 - (22.22)^2 = 2 \times (-2)\, d$

$d = 123.43$ m

∴ The driver would pass the traffic light with a distance

$= 123.43 - 100$ [illegible]

ⓐ 3.1 m/s

$d = v_i t + \frac{1}{2} at^2$

$62.4 = (v_i \times 4.2) + \left(\frac{1}{2} \times (-5.6) \times (4.2)^2\right)$

$v_i = 26.62$ m/s

$v_f = v_i + at = 26.62 - (5.6 \times 4.2) = 3.1$ m/s

The velocity by which the car hits the [illegible]

(i) ⓒ 12 m/s

$(v_f)_1 = (v_i)_1 + a_1 t_1$

$= 0 + (2 \times 6) = 12$ m/s

(ii) ⓓ 426 m

$d_1 = (v_i)_1 t_1 + \frac{1}{2} a_1 t_1^2$

$= 0 + \frac{1}{2} \times 2 \times 6^2 = 36$ m

$d_2 = v_2 t_2 = (v_f)_1 t_2 = 12 \times 30 = 360$ m

$a_3 = \frac{(v_f)_3 - (v_i)_3}{t_3} = \frac{0 - 12}{5} = -2.4$ m/s²

$d_3 = (v_i)_3 t_3 + \frac{1}{2} a_3 t_3^2$

$= 12 \times 5 + \frac{1}{2} \times (-2.4) \times 5^2 = 30$ m

$d = d_1 + d_2 + d_3$

$= 36 + 360 + 30 = 426$ m

(i) ⓒ 4 m/s

$(v_f)_1^2 = (v_i)_1^2 + 2 a_1 d_1$

$= 0 + (2 \times 2 \times 100) = 400$ m²/s²

$(v_f)_1 = 20$ m/s , $(v_i)_2 = (v_f)_1$

$(v_f)_2 = (v_i)_2 + a_2 t_2$

$a_2 = \frac{(v_f)_2 - (v_i)_2}{t} = \frac{0 - 20}{5} =$ [illegible]

(ii) ⓑ 50 m

$d_2 = (v_i)_2 t + \frac{1}{2} a_2 t_2^2$

$= 20 \times 5 + \frac{1}{2} \times (-4) \times (5)^2 = 50$ m

(i) ⓓ 2 m/s²

After 50 s

$v_f = v_i + at$, $v_i = 0$

$v_A = 0 + (a \times 50) = (50\, a)$ m/s

$v_B = 0 + (1.5 \times a \times 50) = (75\, a)$ m/s

$v_B - v_A = 50$, $75\, a - 50\, a = 50$

[illegible]

(ii) ⓑ 1250 m

$a_A = 2$ m/s² , $a_B = 1.5 \times 2 = 3$ m/s²

$\because d = v_i t + \frac{1}{2} at^2$, $v_i = 0$

$\therefore d_B - d_A = \frac{1}{2} a_B t^2 - \frac{1}{2} a_A t^2$

$= \frac{1}{2} \times (3 - 2) \times (50)^2 = 1250$ m

$d = 5t - 3t^2$

By comparing with the second equation of motion

$d = v_i t + \frac{1}{2} at^2$

(i) ⓓ 5 m/s

[illegible]

(ii) ⓐ -6 m/s²

$\frac{1}{2} a = -3 \Rightarrow a = -6$ m/s²

(iii) ⓒ 0.83 s

$v_f = v_i + at$

$0 = 5 + (-6)\, t \Rightarrow t = 0.83$ s

(iv) ⓓ 1 m/s

$v_f^2 = v_i^2 + 2ad = (5)^2 + \left(2 \times (-6) \times 2\right)$

$v_f = 1$ m/s

$t = \frac{1}{2} v_f - 6$

$2t = v_f - 12 \Rightarrow v_f = 12 + 2t$

Comparing with the first equation of motion

$v_f = v_i + at$

(i) ⓑ 12 m/s

$v_i = 12$ m/s

(ii) ⓒ 2 m/s²

[illegible]

(iii) ⓑ 220 m

$d = v_i t + \frac{1}{2} at^2$

$= (12 \times 10) + \left(\frac{1}{2} \times 2 \times (10)^2\right) =$ [illegible]

ⓓ 12 m/s

$t = \sqrt{\frac{2d}{3}}$, $t^2 = \frac{2d}{3}$

$d = \frac{3}{2} t^2$

Comparing with the second equation of motion

$d = v_i t + \frac{1}{2} at^2$

$v_i = 0$, $a = 3$ m/s²

$v_f = v_i + at = 0 + 3 \times 4 = 12$ m/s

$v_f = \sqrt{36 + 5d}$

$v_f^2 = 36 + 5d$

Comparing with the third equation of motion

$v_f^2 = v_i^2 + 2ad$

(i) ⓑ 6 m/s

$v_i^2 = 36 \Rightarrow v_i = 6$ m/s

(ii) ⓐ 2.5 m/s²

$2a = 5 \Rightarrow a = 2.5$ m/s²

(iii) ⓓ 620 m

$d = v_i t + \frac{1}{2} at^2$

$= (6 \times 20) + \left(\frac{1}{2} \times 2.5 \times 20^2\right) = 620$ m

(iv) ⓐ 72.8 m

$v_f^2 = v_i^2 + 2ad$

$(20)^2 = (6)^2 + (2 \times 2.5)\, d$

$d = 72.8$ m

(v) ⓒ 43.5 m/s

$v_f = v_i + at$

$= 6 + (2.5 \times 15) = 43.5$ m/s

ⓑ 50 m/s

$\text{Slope} = \frac{\Delta d}{\Delta t^2} = \frac{25 - 0}{10 - 0} = 2.5$ m/s²

$d = v_i t + \frac{1}{2} at^2$

$\text{Slope} = \frac{1}{2} a = 2.5$ m/s²

$\therefore a = 5$ m/s²

$v_f = v_i + at$

$\therefore v_f = 0 + (5 \times 10) = 50$ m/s

ⓐ 5 m/s², 5.5 s

$\text{Slope} = \frac{\Delta v^2}{\Delta d} = \frac{0 - 60}{6 - 0} = -10$ m/s²

$v_f^2 = v_i^2 + 2ad$

$\text{Slope} = 2a = -10$ m/s²

[illegible]

$v_f = v_i + at$

$0 = \sqrt{60} - 5t$

[illegible]

(i) ⓒ 135 m

- For body A

$a_A = (\text{slope})_A = \frac{60 - 0}{8 - 0} = 7.5$ m/s²

$d_A = (v_i)_A t + \frac{1}{2} a_A t^2$

$= 0 + \left(\frac{1}{2} \times 7.5 \times (6)^2\right) = 135$ m

Another Solution:

Displacement = Area under the (velocity-time) curve

d = Area of the triangle $= \frac{1}{2} \times$ Base $\times$ Height

$\therefore d_A = \frac{1}{2} \times 6 \times 45 = 135$ m

(ii) ⓑ 90 m

- For body B

$a_B = (slope)_B = \frac{40-0}{8-0} = 5\ m/s^2$

$d_B = (v_i)_B t + \frac{1}{2} a_B t^2$

$= 0 + \left(\frac{1}{2} \times 5 \times (6)^2\right) = 90\ m$

Another Solution.

Displacement = Area under the (velocity-time) curve

d = Area of the triangle = $\frac{1}{2}$ × Base × Height

$\therefore d_B = \frac{1}{2} \times 6 \times 30 = 90\ m$

(iii) ⓑ 7.35 s

$d_A = (v_i)_B t + \frac{1}{2} a_B t^2$

$135 = 0 + \left(\frac{1}{2} \times 5\right) t^2$

$t^2 = \frac{135 \times 2}{5} = 54\ s^2$

15 ⓐ $\frac{8}{1}$

$v_f^2 - v_i^2 = 2ad \qquad v_i = 0$

$\therefore v^2 = 2ad \qquad a = \frac{Slope}{2}$

$a_A = \frac{1}{2} \times \frac{4}{1} \ldots = 2\ m/s^2$

$\therefore a_B = \frac{1}{2} \times \frac{1}{2} \ldots = \frac{1}{4}\ m/s^2$

After 5 s

$v_f = v_i + at \qquad v_i = 0$

$\frac{a_A}{a_B} = \ldots = \frac{2}{\frac{1}{4}} = \ldots$

16 ⓒ 11.25 m/s

$d = \bar{v} t = 8 \times 1.5 = 12\ m$

$d = v_i t + \frac{1}{2} at^2 \quad , \quad v_i = 0$

$12 = \frac{1}{2} a (8)^2$

$a = \frac{3}{8}\ m/s^2$

- After 30 s are elapsed.

$v_f = v_i + at$

$= 0 + \left(\frac{3}{8} \times 30\right) = 11.25\ m/s$

Second Essay questions

1 ① The body should move with uniform acceleration.

② The body should move in a straight line.

③ The body should start its motion from rest.

2 (a) The slope of the line graph of velocity versus time represents the acceleration of the body.

$a_A = (slope)_A = \frac{v_o - 0}{2t_o - 0} = \frac{v_o}{2t_o}$

$a_B = (slope)_B = \frac{2v_o - 0}{t_o - 0} = \frac{2v_o}{t_o}$

The body (B) moves with a greater acceleration than (A), because the slope of the straight line that represents the motion of (B) is larger than that of (A).

(b) $d_B = \frac{1}{2} a_B t_B^2 = \frac{1}{2} \times \frac{2v_o}{t_o} \times t_o^2 = v_o t_o$

$d_A = \frac{1}{2} a_A t_A^2 = \frac{1}{2} \times \frac{v_o}{2t_o} \times 4 t_o^2 = v_o t_o$

The two bodies cover equal distances.

Another Solution:

d_A = The area under the curve

$= \frac{1}{2} \times 2 \times t_o \times v_o = v_o t_o$

$d_B = \frac{1}{2} \times t_o \times 2 \times v_o = v_o t_o$

The two bodies cover the same distance.

3 (a) Because the distance covered by the ball each 0.5 s increases.

(b) $a = \frac{2d}{t^2} = \frac{2 \times 2}{(1.5)^2} = 1.78\ m/s^2$

4 ∵ The body starts its motion at x_i and ends it at x_f

The displacement covered by the body is.

$d = x_f - x_i$

The body moves with uniform acceleration.

$\therefore \bar{v} = \frac{v_i + v_f}{2}$

$d = \bar{v} t$

$x_f - x_i = \frac{1}{2} (v_i + v_f) t$

$\therefore x_f = x_i + \frac{1}{2} (v_i + v_f) t$

Answers of questions that measure high levels of thinking

1 ⓓ $2.15\ m/s^2$, 9.68 m

From t = 0 to t = 3 s:

$\because d_1 = v_i t + \frac{1}{2} at^2$

$d_1 = 0 + \left(\frac{1}{2} a \times (3)^2\right)$

$d_1 = \left(\frac{9}{2} a\right)$ m

$v_f = v_i + at$

$v = 0 + 3a$

$\therefore v = (3a)$ m/s ②

From t = 3 s to t = 17 s:

$d_2 = vt$ ③

Substituting from ② in ③:

$d_2 = 3a \times (17 - 3)$

$d_2 = (42a)$ m

$\because d_1 + d_2 = 100$ m

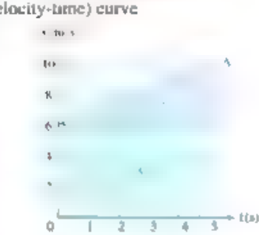
$\left(\frac{9}{2} a\right) + (42a) = 100$

Substituting in

$= \frac{9}{2} \times 2.15 =$

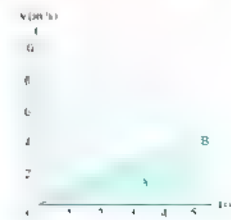
2 ⓒ 30 m

Displacement = The area under the (velocity-time) curve



$d_A = A_1 + A_2$

$= \left(\frac{1}{2} \times 5 \times 4\right) + (6 \times 5) = 40\ m$



$d_B = A_3 = \frac{1}{2} \times 5 \times 4 = 10\ m$

$d = d_A - d_B = 40 - 10 = 30\ m$

3 ⓒ 800 m

$d = v_i t + \frac{1}{2} at^2 \quad , \quad v_i = 0$

After time t

$Car_1: d_1 = \frac{1}{2} at^2$

$Car_2: d_2 = \frac{1}{2} (2a) t^2 = at^2$

$d_2 - d_1 = at^2 - \frac{1}{2} at^2 = \frac{1}{2} at^2$

$\therefore 200\ m = \frac{1}{2} at^2 \Rightarrow at^2 = 400\ m$

- After time 2 t:

$Car_1: d_1' = \frac{1}{2} a (2t)^2 = 2at^2$

$Car_2: d_2' = \frac{1}{2} (2a)(2t)^2 = 4at^2$

$d_2' - d_1' = 4at^2 - 2at^2 = 2at^2$

$\therefore \Delta d = 2 (400) = 800\ m$

The distance between the two cars after time 2 t from the start of motion is 800 m.

4 (i) ⓐ 5 s

For the deer: $d = vt \Rightarrow y = 2t$ ①

For the tiger: $d = v_i t + \frac{1}{2} at^2$

$15 + y = 0 + \frac{1}{2} \times 2 t^2$

$15 + y = t^2$ ②

From ① and ②

$15 + 2t = t^2 \qquad t^2 - 2t - 15 = 0$

$(t - 5)(t + 3) = 0$

t = 5 s such that time is always positive.

(ii) ⓐ 25 m

Substituting by t in ①

$y = 2 \times 5 = 10\ m$

The tiger will catch the deer after running a distance of 25 m.

5 ⓑ 4 km

$d = v_i t + \frac{1}{2} at^2 \quad , \quad v_i = 0$

$d_A = \frac{1}{2} a_A t_A^2$

$t_A = \sqrt{\frac{2 d_A}{a_A}} = \sqrt{\frac{2 \times 9.8 \times 10^3}{4}} = 70 \text{ s}$

$t_B = t_A + 30 = 70 + 30 = 100 \text{ s}$

$d_B = v_B t_B = 40 \times 100 = 4000 \text{ m} = 4 \text{ km}$

6 (b) 4 s

$v_i = \sqrt{v_f^2 - 2 ad}$

$= \sqrt{(5.35)^2 - (2 \times -2.77 \times 45)}$

$= 16.67 \text{ m/s}$

$t = \frac{v_f - v_i}{a} = \frac{5.35 - 16.67}{-2.77} = 4 \text{ s}$

7 (c) 12 s

$v_f = v_i + at_1$

$2 = 0 + 0.5 t_1$

$t_1 = 4 \text{ s}$

$v_f^2 = v_i^2 + 2 ad$

$(2)^2 = 0 + (2 \times 0.5 d_1)$

$d_1 = 4 \text{ m}$

$d_2 = d - d_1 = 20 - 4 = 16 \text{ m}$

$v = \frac{d_2}{t_2}$

$t_2 = \frac{d_2}{v} = \frac{16}{2} = 8 \text{ s}$

$t = t_1 + t_2$

$= 4 + 8 = 12 \text{ s}$

8 (c) $d = v_f t - \frac{1}{2} at$

From first equation of motion

$v_f = v_i + at$

$v_i = v_f - at$ (1)

From second equation of motion

$\therefore d = v_i t + \frac{1}{2} at^2$ (2)

From (1) and (2)

$d = (v_f - at) t + \frac{1}{2} at^2 = v_f t - at^2 + \frac{1}{2} at^2$

9 (d) 20 m

The acceleration of the car

$a = \frac{v_f - v_i}{t} = \frac{10 - 30}{5} = -4 \text{ m/s}^2$

The distance covered after 3 s:

$d = v_i t + \frac{1}{2} at$

$d_3 = (30 \times 3) + \left(\frac{1}{2} \times (-4) \times (3)^2\right) = 72 \text{ m}$

- The distance covered after 2 s:

$d_2 = (30 \times 2) + \left(\frac{1}{2} \times (-4) \times (2)^2\right) = 52 \text{ m}$

The distance covered in the third second only

$= d_3 - d_2 = 72 - 52 = 20 \text{ m}$

10 To verify the validity of this situation, we will find the value of acceleration from two different equations

$a_1 = \frac{v_f - v_i}{t} = \frac{8 - 0}{10} = 0.8 \text{ m/s}^2$

$d = v_i t + \frac{1}{2} a_2 t^2 = \frac{1}{2} a_2 t^2$

$a_2 = \frac{2d}{t^2} = \frac{2 \times 50}{(10)^2} = 1 \text{ m/s}^2$

The situation is impossible because the acceleration has two different values.

Chapter 2 Lesson Two

First Multiple choice questions

1 (b) velocity

2 (d) They reach the ground at the same time

3 (d) $d = \frac{1}{2} gt^2$

4 (a) 29.4 m/s

5 (a) 1.43 s, 1.43 s

The two bodies fall from the same height at the same instant

They take the same time to reach the ground

$d = v_i t + \frac{1}{2} gt^2$

$10 = 0 + \left(\frac{1}{2} \times 9.8 t^2\right)$

6 (b) 1.6 m/s²

$d = v_i t + \frac{1}{2} g_{moon} t^2$

$3.2 = 0 + \left(\frac{1}{2} \times g_{moon} \times 2^2\right)$

$3.2 = 2 g_{moon}$

$g_{moon} = \frac{3.2}{2} = 1.6 \text{ m/s}^2$

7 (i) (a) 9.9 m/s

$v_f^2 = v_i^2 + 2 gd$

$v_f^2 = 0 + (2 \times 9.8 \times 5)$

$v_f = 9.9 \text{ m/s}$

(ii) (a) 1.01 s

$v_f = v_i + gt$

$9.9 = 0 + 9.8 t$

$t = 1.01 \text{ s}$

8 (d)

9 (c) 9.88 m/s²

$t = \frac{\text{Total time}}{\text{Number of drops}} = \frac{45}{100} = 0.45 \text{ s}$

$d = v_i t + \frac{1}{2} gt^2$, $v_i = 0$

$g = \frac{2d}{t^2} = \frac{2 \times 1}{(0.45)^2}$

10 (d) $\frac{1}{\sqrt{2}}$

$v_f^2 = v_i^2 + 2 gd$, $v_i = 0$

$v_f^2 = 2 gd$

$v_f \propto \sqrt{d}$

$= \sqrt{\frac{d_{AB}}{d_{AC}}} = \sqrt{\frac{3}{6}} =$

11 (c) $v_1 < v_2$, $t_1 > t_2$

From the second equation of motion

$d = v_i t + \frac{1}{2} gt^2$

The two balls fall from rest

$t^2 = \frac{2d}{g}$

$\therefore t = \sqrt{\frac{2d}{g}}$

The two balls fall from equal heights.

$t \propto \frac{1}{\sqrt{g}}$

$g_{moon} < g_{Earth}$

- From the second equation of motion.

$v_f^2 = v_i^2 + 2 gd$

$v_f^2 \propto g$

$v_1 < v_2$

12 (c) $\frac{v^2}{2}$

- After covering 1 m from the start of motion.

$\therefore v_f^2 - v_i^2 = 2 gd$, $v_i = 0$

$\therefore v^2 = 2 g \times 1 = 2 g \Rightarrow g = \left(\frac{v^2}{2}\right) \text{ m/s}^2$

After passing 1 s from the start of motion

$v_f = v_i + gt$, $v_i = 0$

$v_f = g \times 1 = (g) \text{ m/s}$

From the equations and

13 (c) 9.19 m

- The velocity of hitting the surface of water

$v_f^2 = v_i^2 + 2 gd$

$v_f^2 = 0 + (2 \times 10 \times 10) = 200$

$v_f = 14.14 \text{ m/s}$

When it starts to dive its average velocity

$\bar{v} = \frac{1}{10} v_f = \frac{1}{10} \times 14.14 = 1.414 \text{ m/s}$

$d = \bar{v}t = 1.414 \times 6.5 = 9.19 \text{ m}$

$\therefore$ The depth = 9.19 m

14 (c) $\frac{1}{\sqrt{2}}$

$d_1 = v_i t_1 + \frac{1}{2} gt_1^2$, $v_i = 0$

$t_1 = \sqrt{\frac{2 d_1}{g}}$

$t_2 = \sqrt{\frac{2 d_2}{g}}$, $d_2 = 2 d_1$

$= \sqrt{\frac{2 d}{g} \times \frac{g}{4 d}}$

15 (b) $\frac{a_A}{a_B} = 1$

16 (a) the two balls return to the level of projection together

17 (i) (c) upwards, downwards

(ii) (a) downwards, downwards

18 (b) 0, g

19 ⓓ $\frac{2\sqrt{5}}{5}$ s

$v_f^2 - v_i^2 = 2gd$

$0 = v_i^2 - (2 \times 10 \times 1)$

$v_i = 2\sqrt{5}$ m/s

$v_f = v_i - gt$

$0 = 2\sqrt{5} - (10\, t_1)$

- Time of ascending:

$t_1 = \frac{\sqrt{5}}{5}$ s

- The time taken by the player for the whole jump.

$= 2\, t_1 = 2 \times \frac{\sqrt{5}}{5} = \frac{2\sqrt{5}}{5}$

20 (i) ⓐ 39.6 m/s

$v_f^2 = v_i^2 + 2gd$

$0 = v_i^2 + 2 \times (-9.8) \times 80$

$v_i = 39.6$ m/s

(ii) ⓓ 8.08 s

$v_f = v_i + gt$

$0 = 39.6 - 9.8\, t$

$t = 4.04$ s

And this is only the time of ascending

The time of ascending from the launching point to the maximum height = The time of falling down from the maximum height to the launching point.

The time taken by the body to return back to the launching point

Time of flight $= 2\, t = 8.08$ s

21 (i) ⓒ 49 m/s

$v_f = v_i + gt$

$= 98 - (9.8 \times 5) = 49$ m/s

(ii) ⓕ 490 m

$v_f^2 - v_i^2 = 2gd$

$0 - (98)^2 = 2 \times (-9.8)\, d$

(iii) ⓓ 20 s

$v_f = v_i + gt$

$0 = 98 - 9.8\, t$

$t = 10$ s

And this is only the time of ascending

The time of ascending from the launching point to the maximum height = The time of falling down from the maximum height to the launching point

Total time $= 2\, t = 2 \times 10 = 20$

22 (i) ⓑ 4 s

$v_f = v_i + gt$

$t = \frac{v_f - v_i}{g} = \frac{20 - 60}{-10}$

(ii) ⓒ 160 m

$v_f^2 = v_i^2 + 2gd$

$(20)^2 = (60)^2 + (2 \times -10)\, d$

23 ⓑ 120 m

$d = v_i t + \frac{1}{2} g t^2$

$= (10 \times 4) + \left(\frac{1}{2} \times 10 \times (4)^2\right) = 120$ m

24 ⓐ 25 ⓐ

26 (i) ⓑ 5 s

The velocity of the body decreases uniformly as it rises upward till it reaches zero at the maximum height

The time interval taken by the body to reach the maximum height = 5

(ii) ⓒ 125 m

$g = \text{Slope} = \frac{0 - 50}{5 - 0} = -10$ m/s^2

$v_f^2 = v_i^2 + 2gd$

$0 = (50)^2 + (2 \times -10)\, d$

27 ⓐ zero

28 ⓒ 4 h

$v_f^2 - v_i^2 = 2gd$ $v_f = 0$

29 ⓒ $v_A = v_B \neq 0$

The two objects have the same velocity at the same point (launching point)

The two objects reach the ground with the same velocity

$v_A = v_B \neq 0$

30 ⓒ 25 m/s

Second Essay questions

1 It is not necessary that its acceleration = Zero at this instant

Example:

When a body is projected vertically upwards its velocity at the maximum height equals zero while it moves at an acceleration which is equal to the free fall acceleration.

2 Because the Earth shape is not completely spherical but it is ellipsoid, where its equatorial diameter is bigger than its polar diameter, so the free fall acceleration varies depending on the distance from the Earth's center

3 (1) Because the body moves under the effect of the force of gravity with uniform acceleration 9.8 m/s^2 (acceleration due to gravity) that makes its velocity increases till it reaches its maximum value at the moment of hitting the ground

(2) Because the body moves against the force of gravity with a negative acceleration so its velocity decreases till it vanishes at the maximum height

(3) Because zero acceleration means that the object moves with a constant velocity which is different than what is happening at the maximum height where the velocity decreases gradually until it reaches zero at the maximum height then it changes its direction and increases again till it reaches the ground which means that the body has acceleration

4 Both of them are equal, because they are falling by the same acceleration which is the free fall acceleration.

5 (a) A body is projected upwards and returns back to the same level of projection

(b) (A) represents the initial velocity at the instant of projection

(C) represents the instant of returning back to the same level of projection

Velocity at (A) = Velocity at (C)

(c) (B) represents the instant of reaching the maximum height where the velocity equals zero

6 (a) Line A, because on calculating the slope

$a_A = \frac{0 - 50}{5 - 0} = -10$ m/s^2

Which is the free fall acceleration on Earth

(b) The difference of the acceleration due to gravity on Earth's surface and Moon's surface

(c) Slope $= a_B = \frac{0 - 50}{x - 0} = \frac{-5}{3}$

$x = \frac{50 \times 3}{5} = 30$ s

(d) The slopes will be the same, because the free fall acceleration does not depend on the mass of the falling object.

Answers of questions that measure high levels of thinking

1 (i) ⓑ 58.8 m/s

$v_f = v_i + gt$

$= 0 + 9.8 \times 6 = 58.8$ m/s

(ii) ⓒ 176.4 m

$v_f^2 = v_i^2 + 2gd$

$(58.8)^2 = 0 + (2 \times 9.8)\, d$

(iii) ⓐ 98 m

The velocity of the object at the end of the fourth second = its velocity at the beginning of the last two seconds

$v_f = v_i + gt$

$= 0 + (9.8 \times 4) = 39.2$ m/s

During the last two seconds

$d = v_i t + \frac{1}{2} g t^2$

$= (39.2 \times 2) + \left(\frac{1}{2} \times 9.8 \times (2)^2\right) = 98$ m

3 ⓒ 5.36 s

The time taken by the stone to reach the water

$\because d = v_i t + \frac{1}{2} g t^2$, $v_i = 0$

$122.5 = \frac{1}{2} \times 9.8 \times t^2$

$t = 5$ s

The time taken by the sound to cover the distance 122.5 m in air

$t_2 = \frac{d}{v_{sound}} = \frac{122.5}{343} = 0.36$ s

The time taken to hear the sound of hitting the water

$t = t_1 + t_2 = 5 + 0.36 = 5.36$ s

4 ⓑ $\sqrt{2}$ s

$\because$ The two stones fall from rest

The time intervals for the two stones motions are equal

The time difference between the arrivals of the two stones to the ground = The time interval taken by the first stone to cover 10 m.

$d = v_i t + \frac{1}{2} g t^2$

$10 = 0 + (\frac{1}{2} \times 10 t^2)$

$\therefore t = \sqrt{2}$ s

5 ⓓ [illegible]

- The time of motion of the object from the building's top to the ground:

$t = t_1 + t_2$

$d = v_i t + \frac{1}{2} g t^2$, $v_i = 0$

[illegible]

The time taken by the body to cover the other half of the building

[illegible]

5 ⓒ $5\sqrt{2}$ m/s

Body A

$d_A = v_i t + \frac{1}{2} g t^2$

$40 = 0 + (\frac{1}{2} \times 10 \times t^2)$

$t = 2\sqrt{2}$ s

Body B:

$d_B = v_i t + \frac{1}{2} g t^2$

$60 = (v \times 2\sqrt{2}) + (\frac{1}{2} \times 10 \times (2\sqrt{2})^2)$

$20 = 2\sqrt{2}\, v$

$\therefore v = 5\sqrt{2}$ m/s

6 ⓒ 50 m

- When projecting the ball upwards and reaching the maximum height

$v_f^2 - v_i^2 = 2 g d$

$0 - v_i^2 = 2 \times (-10) \times h_1$

$v_i^2 = (20 h_1)$ m²/s²

- When the ball falls from the maximum height to the ground.

$(2 v)^2 - 0 = 2 \times 10 \times (h_1 + 30)$

$\therefore 4 v^2 = 20 h_1 + 600$ ②

By substituting ① in ②:

$\therefore 4 (20 h_1) = 20 h_1 + 600$

$60 h_1 = 600$

$h_1 = 10$ m

- The total distance covered by the ball

$s = 10 + 10 + 30 = 50$ m

7 ⓒ 25 m/s

$(v_f^2)_A = (v_i^2)_A + 2 g d_A$

$0 = (20)^2 + (2 \times (-10) d_A)$

$d_A = 20$ m

$(v_f)_A = (v_i)_A + g t_A$

$0 = 20 - 10 t_A$

$t_A = 2$ s

$t_B = t_A - 1 = 2 - 1 = 1$ s

$d_B = (v_i)_B t_B + \frac{1}{2} g t_B^2 = d_A$

$20 = (v_i)_B \times 1 + (\frac{1}{2} \times (-10) \times (1)^2)$

$(v_i)_B = 25$ m/s

Chapter 2 Lesson Three

First Multiple choice questions

1 ⓐ $\frac{1}{2}$ T

2 ⓒ 40° and 50°

3 (i) ⓐ 10 m/s

$v_{ix} = v_i \cos\theta = 20 \cos 60° = 10$ m/s

(ii) ⓑ $10\sqrt{3}$ m/s

$v_{iy} = v_i \sin\theta = 20 \sin 60° = 10\sqrt{3}$ m/s

(iii) ⓓ 7.32 m/s

$v_{fy} = v_{iy} - g t = 17.32 - (10 \times 1) = 7.32$ m/s

4 ⓐ

5 (i) ⓒ 20 m

(ii) ⓑ 80 m

6 ⓐ 5 m

$v_{iy} = v_i \sin\theta$

$= 20 \sin 30 = 10$ m/s

$h = \frac{-v_{iy}^2}{2g} = \frac{-(10)^2}{2 \times (-10)} = 5$ m

7 (i) ⓒ 15 m

$v_{iy} = v_i \sin\theta = 20 \sin 60 = 10\sqrt{3}$ m/s

$h = \frac{-v_{iy}^2}{2g} = \frac{-(10\sqrt{3})^2}{2 \times (-10)} = 15$ m

(ii) [illegible] 34.64 m

$R = \frac{2 v_i^2 \sin\theta \cos\theta}{g}$

$= \frac{2 \times (20)^2 \times \sin 60 \times \cos 60}{10} =$ [illegible]

8 (i) ⓑ 40 m/s

$T = \frac{2 v_{iy}}{g}$

$v_{iy} = \frac{g T}{2} = $ [illegible] $= 20$ m/s

$v_{iy} = v_i \sin\theta$

$20 = v_i \sin 30$

$v_i = 40$ m/s

(ii) ⓑ $20\sqrt{3}$ m/s

$v_{ix} = v_i \cos\theta = 40 \cos 30 = 20\sqrt{3}$ m/s

(iii) ⓑ 20 m

$h = \frac{-v_{iy}^2}{2g} = \frac{-(20)^2}{2 \times (-10)} = 20$ m

9 ⓑ 100 m/s

$R = v_{ix} t = \frac{2 v_{ix} v_{iy}}{g}$

$v_{ix} = v_i \cos\theta$, $v_{iy} = v_i \sin\theta$

$R = \frac{2 v_i^2 \sin\theta \cos\theta}{g}$

$1000 = \frac{2 v_i^2 \sin 45 \cos 45}{10}$

$v_i^2 = 10000$

$v_i = 100$ m/s

10 (i) ⓓ 25.22 m/s, 93.2 m

$v_{ix} = v_i \cos\theta = 50 \cos 60° = 25$ m/s

$v_{iy} = v_i \sin\theta = 50 \sin 60° = 43.3$ m/s

$v_{fx} = v_{ix} = 25$ m/s

$v_{fy} = v_{iy} + g t = 43.3 - (10 \times 4) = 3.3$ m/s

$v_f = \sqrt{v_{fx}^2 + v_{fy}^2} = \sqrt{(25)^2 + (3.3)^2} = 25.22$ m/s

$y = v_{iy} t + \frac{1}{2} g t^2$

$= (43.3 \times 4) - (\frac{1}{2} \times 10 \times (4)^2) = 93.2$ m

(ii) ⓒ 64.03 m/s, 80 m

$v_{ix} = v_i \cos\theta = 50 \cos 0 = 50$ m/s

$v_{iy} = v_i \sin\theta = 50 \sin 0 = 0$

$v_{fx} = v_{ix} = 50$ m/s

$v_{fy} = v_{iy} + g t = 0 + (10 \times 4) = 40$ m/s

$v_f = \sqrt{v_{fx}^2 + v_{fy}^2}$

$= \sqrt{(50)^2 + (40)^2} =$ [illegible] m/s

$y = v_{iy} t + \frac{1}{2} g t^2 = 0 + (\frac{1}{2} \times 10 \times (4)^2) = 80$ m

11 (i) ⓒ 230.94 m/s

$h = \frac{-v_{iy}^2}{2 g}$

$v_{iy}^2 = -2 g h = -2 \times (-10) \times 2000 = 40000$

$v_{iy} = 200$ m/s

$v_i = \frac{v_{iy}}{\sin\theta} = \frac{200}{\sin 60} =$ [illegible] m/s

(ii) ⓒ 701.74 m/s

$v_{ix} = v_i \cos\theta = 800 \cos 80° = 138.92$ m/s

$v_{iy} = v_i \sin\theta = 800 \sin 80° = 787.85$ m/s

$v_{fx} = v_{ix} = 138.92$ m/s

$v_{fy} = v_{iy} + gt$

$= 787.85 - (10 \times 10) = 687.85$ m/s

$v_f = \sqrt{v_{fx}^2 + v_{fy}^2}$

$= \sqrt{(138.92)^2 + (687.85)^2} = 701.74$ m/s

(iii) ⓒ 45°

12 ⓑ 158 m/s

$h = v_{iy} t + \frac{1}{2} g t^2 \quad \because v_{iy} = 0$

$\therefore t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 200}{10}} = 6.325$ s

$v_i = v_{ix} = \frac{d}{t} = \frac{1000}{6.325} = 158$ m/s

13 (i) ⓐ 70.71 s

$v_{iy} = v_i \sin\theta = 1000 \sin 45° = 707.1$ m/s

[illegible]

(ii) ⓑ 141.42 s

$T = 2t = 2 \times 70.71 = 141.42$ s

(iii) ⓒ 100 km

$v_{ix} = v_i \cos\theta = 1000 \cos 45° = 707.1$ m/s

$R = 2 v_{ix} t = 2 \times 707.1 \times 70.71$

$= 100000$ m $= 100$ km

14 (i) ⓒ 45 m

[illegible]

(ii) ⓓ 311.76 m

$v_i = \frac{v_{iy}}{\sin\theta} = \frac{30}{\sin 30} = 60$ m/s

$v_{ix} = v_i \cos\theta = 60 \cos 30° = 51.96$ m/s

$R = v_{ix} T = 51.96 \times 6 = 311.76$ m

15 (i) ⓒ 30 m/s

At T = 6 s:

$\theta = 45°$

$= v_{iy} = 30$ m/s

(ii) ⓒ 500 m

At T = 10 s:

$v_{ix} = v_{iy} = 50$ m/s

$R = v_{ix} T = 50 \times 10 = 500$ m

16 ⓒ 44°

$\because R = v_{ix} T = \frac{2 v_{ix} v_{iy}}{g}$

$= \frac{-2 v_i^2 \sin\theta \cos\theta}{g} = \frac{-v_i^2 \sin 2\theta}{g}$

$\therefore R \propto \sin 2\theta$

$\sin 2\theta_{(A)} : \sin 2\theta_{(B)} : \sin 2\theta_{(C)} : \sin 2\theta_{(D)}$

$= \sin(2 \times 90) : \sin(2 \times 75) : \sin(2 \times 44) : \sin(2 \times 30)$

$= 0 : 0.5 : 0.999 : 0.87$

The object reaches a greater horizontal range when it is launched at an angle of 44°

17 [illegible]

$R = v_{ix} T = \frac{2 v_{ix} v_{iy}}{g}$

$= \frac{-2 v_i^2 \sin\theta \cos\theta}{g} = \frac{-v_i^2 \sin 2\theta}{g}$

The projectile is launched at the same launching angle and from the same point

$R \propto v_i^2$

$\therefore \frac{R_1}{R_2} = \frac{(v_i)_1^2}{(v_i)_2^2} = \frac{v^2}{(\frac{v}{2})^2} = \frac{4}{1}$

18 ⓒ horizontal range

19 ⓑ $20\sqrt{2}$ m/s, 45°

$\because v_{ix} = v_{iy}$

$v_i \cos\theta = v_i \sin\theta$

$\frac{\sin\theta}{\cos\theta} = \tan\theta = 1$

$\therefore \theta = 45°$

$\because v_{ix} = v_i \cos\theta$

$\therefore 20 = v_i \cos 45$

$\therefore v_i = 20\sqrt{2}$ m/s

20 ⓓ 160 m/s

$\because v_{iy} = v_i \sin\theta$

$\therefore v_{iy} = v_i \sin 30$

$\therefore v_{iy} = \frac{1}{2} v_i$

$\because v_{fy} = v_{iy} + gt$

$\therefore \frac{1}{4} v_i = \frac{1}{2} v_i - (10 \times 4)$

$\frac{1}{4} v_i = 40$

$\therefore v_i = 160$ m

21 ⓒ 63.43°

$v_{iy} = 2 v_{ix}$

$v_i \sin\theta = 2 v_i \cos\theta$

$\frac{\sin\theta}{\cos\theta} = \tan\theta = 2$

$\therefore \theta = 63.43°$

22 (i) ⓓ 1 = 2 = 3

[illegible]

∴ The maximum height reached by the ball in the three paths is the same

The vertical initial velocity of the ball in the three paths is the same

[illegible]

(ii) ⓓ 1 = 2 = 3

[illegible]

The vertical initial velocity of the ball in the three paths is the same

The flight time in the three paths is the same

[illegible]

(iii) ⓑ 1 < 2 < 3

$\because R = v_{ix} T$

∵ The flight time in the three paths is the same

$R \propto v_{ix}$ [illegible]

(iv) ⓑ 1 < 2 < 3

[illegible]

$\therefore 1 < 2 < 3$

23 (i) ⓒ $20\sqrt{2}$ s

∵ The bomb fell from a plane that is flying horizontally

∴ The initial velocity of the bomb equals the horizontal velocity only which is equal to the plane's velocity

- The time taken by the bomb to reach the target:

$\because d = v_{iy} t + \frac{1}{2} g t^2 \quad , \quad v_{iy} = 0$

$\therefore 4000 = 0 + \frac{1}{2} \times 10 \times t^2$

$\therefore t = \sqrt{800} = 20\sqrt{2}$ s

(ii) ⓒ 2828.4 m

- The horizontal range of the bomb:

$R = v_{ix} T = v_i t = 100 \times 20\sqrt{2} = 2828.4$ m

(iii) ⓑ 300 m/s

- The final velocity of the bomb:

[illegible]

Second Essay questions

1 (a) The horizontal component of the bag's velocity [illegible]

[illegible]

(b) The maximum height reached by the bag [illegible]

[illegible]

The vertical component of the bag's velocity decreases by increasing the height from the ground

[illegible]

(c) [illegible]

2 3 > 2 > 1

In the projectiles motion, the final velocity of the body equals its initial velocity when the projectile lands to a point at the same level of the projection point. If the body lands [illegible] final velocity will be greater than [illegible] velocity but if it lands before [illegible] final velocity will be less than its initial velocity

Answers of questions that measure high levels of thinking

1 ⓑ the second [illegible]

[illegible]

The three balls are projected with the same speed (magnitude of velocity)

[illegible]

$= 1 : 0.707 : 0.866$

The ball that reaches the ground first is the ball that has taken less time of ascending

The correct choice is (b)

2 (b) 45°

$R = 4h$

$\frac{2 v_y v_x}{g} = 4 \times \frac{v_y^2}{2g}$

$\therefore v_x = v_y$

$v_i \cos\theta = v_i \sin\theta$

$\frac{\sin\theta}{\cos\theta} = 1$

$\tan\theta = 1$

3 (a)

$\theta = 45°$

$v_{ix} = v_{iy}$

The horizontal component of the projectile's velocity (v_x) is constant ... The vertical component of the projectile's velocity (v_y) decreases ... during the ascending of the projectile from the ground till reaching the maximum height, then ... increases uniformly ... back to the ground

The correct choice is (a)

4 (i) (b) 4.16 s

The time taken by the ball to reach the same level of projection

$t_1 = \frac{-2 v_{iy}}{g} = \frac{-2 v_i \sin\theta}{g}$

$= \frac{-2 \times 20 \times \sin 30}{-10}$

The time taken by the ball ... the ground from the same level of projection

$45 = 10 ...$

(ii) (d) 72.05 m

$x = R = v_{ix} T = 20 \cos(30) \times 4.16 = 72.05$ m

5 (b) 5.36 m

$v_{ix} = v_i \cos\theta = 20 \cos 40° = 15.32$ m/s

$d = v_x t$

$v_{iy} = v_i \sin\theta = 20 \sin 40° = 12.86$ m/s

$h = v_{iy} t + \frac{1}{2} g t^2$

$= 12.86 \times 0.52 + \frac{1}{2} \times (-9.8) \times (0.52)^2$

$= 5.36$ m

6 • Windows (1, 2 and 3)

• The vertical velocity of the ball decreases as its height increases

$\therefore$ The average velocity of the ball decreases by increasing its height

$1 > 2 > 3$

• Windows (4, 5 and 6)

The vertical velocity of the ball increases while descending

• The average velocity of the ball increases while descending

$6 > 5 > 4$

Answers of Test on Chapter 2

The height of the balcony = The height of the building − The distance moved by the stone

$h = 100 - 80 = 20$ m

12 (d) 3 m/s²

13 (c) 25 m/s

First interval:

$d = v_i t + \frac{1}{2} a t^2$

$100 = 0 + \frac{1}{2} (2) t^2$

$t = 10$ s

$v_f = v_i + at$

$= 0 + (2)(10) = 20$ m/s

Second interval

$d = v_i t + \frac{1}{2} a t^2$

$= 20 \times 10 + \frac{1}{2} (4) \times 10$

$\therefore$ Average velocity $= \frac{100 + 400}{10 + 10} = 25$ m/s

14 550 m

$v_{ix} = v_i \cos\theta = 55 \cos(0) = 55$ m/s

$v_{iy} = v_i \sin\theta = 55 \sin(0) = 0$ m/s

$\therefore h = v_{iy} t + \frac{1}{2} g t^2$

$500 = 0 + \frac{1}{2} \times 10 t^2 \Rightarrow t = 10$ s

$\therefore x = v_x t = 55 \times 10$

15 The distance moved by the body has to be measured from the instant at which the body was at rest

The body has to be moving in a straight line

16 • The projected ball

$v_{fx} = v_{ix} = v$

• The free falling ball

$v_i = 0$

$h = v_i t + \frac{1}{2} g t^2 = \frac{1}{2} g t^2$

$t = \sqrt{\frac{2h}{g}}$ (2)

From (1) and (2)

Both bodies reach the ground at the same time ...

Chapter 3

First Multiple choice questions

1 (a) inertia

2 (b) backward

3 (a) forward

4 (a) zero

5 (d) 0

6 (a) $F_3 = F_1 + F_2$

The (v-t) graph represents the motion of a body with uniform (constant) velocity

$\Sigma F = 0$

7 (b)

The body moves with uniform velocity

The two forces ... are opposite to each other

The correct choice is (b)

8 (a) AB

The body moves with uniform velocity when the net force acting on it is zero and this is what happens during the interval ...

9 ... move in the direction ...

When the ... the direction of ... the ... gets affected by a reaction force that has the same magnitude ... in the opposite direction ...

14 (a) F upwards

When body X acts ... force F ... body Y ... direction upwards

The correct choice is (a)

Second Essay questions

1. No, the body can't be in an equilibrium state because the condition of equilibrium is the absence of the resultant forces that affect the body ($\sum F = 0$)
2. Because in fact you don't feel the motion but you feel the force that causes the [illegible] force [illegible] the change of motion and since you are inside the plane which is moving with [illegible] velocity so the resultant force [illegible] equals zero so you will not feel [illegible] and you can't distinguish [illegible]
3. (1) Because the [illegible] of the bicycle keeps at moving [illegible] stops due to the effect of [illegible] forces
   (2) Because Newton's first law states that the object can't change its state of [illegible] in a straight line by itself
   (3) Because the upper part of the body [illegible] keep its state of rest [illegible] goes back [illegible] due to inertia
   (4) Because the upper part of the body tries to keep its state of motion [illegible] due to inertia
   (5) Because inertia keeps it moving in a straight line with a uniform velocity
   (6) In order to reduce the recoil [illegible] back as a reaction when the bullet is fired
4. (1) Case (a) and case [illegible]
   (2) Case (a) and case [illegible]
5. Inertia
6. The coin falls into the cup because the coin tries by inertia to keep its state of rest
7. To reduce the body's rush [illegible] during the collision due to its inertia [illegible] reduce the possibility of injuries
8. (1) Action force: The force of the man's [illegible] the ground
   Reaction force: The force of the ground on the man's feet
   (2) Action force: The force of the goalkeeper's hands that acts on the ball
   Reaction force: The force of the ball that acts on the hands of the goalkeeper
   (3) Action force: The force of the air molecules that acts on the window
   Reaction force: The force of the window that acts on the air molecules

Answers of questions that measure high levels of thinking

1. [illegible] 100 N
   Draw [illegible] for the forces vectors as [illegible] then resolve each of F [illegible]
   The three balances are in equilibrium
   $\sum F = 0$
   [illegible]

2. Increase the magnitude of $\vec{F}$
   By decreasing the angle (θ) the value of the horizontal component of F increases so we have [illegible] so that the forces that act on the body be in equilibrium state and the body moves with the same velocity
3. 1. Increasing the angle θ
   2. Decreasing the magnitude of force $\vec{F}$

Answers of Test on Chapter 3

1. 600 N
2. acceleration
3. [illegible]
4. Action force and reaction force are acting on the same body
5. ⓓ equal to zero
6. the force that acts on the book by the table
7. ⓐ
8. ⓓ
9. ⓓ
10. AB
11. [illegible] 10 N
12. [illegible]
13. ⓓ [illegible] N, 5 N
14. [illegible] N, $10\sqrt{3}$ N
15. By burning fuels to generate an amount of gases to rush from the rocket in a direction opposite to the required direction to generate a reaction for pushing the rocket

16. No, it won't increase because the reaction force by which the table affects the body is perpendicular on the acting force on the body

Answers of Accumulative Test on Units 1 & 2

1. ⓓ undefined
2. ⓐ (3000 ± 600) kg
3. ⓒ 5.13 F
4. ⓑ 45
5. ⓒ the velocity of the body decreases with time
6. ⓑ -5.4×10^3 km/h^2
7. ⓑ 332.1 m
8. ⓒ They have equal ranges.
9. ⓑ velocity
10. ⓑ reaction
11. ⓑ $\frac{\pi}{2}$ m/s, $\sqrt{2}$ m/s
12. ⓒ 128 m

$d_1 = vt = 4 \times 8 = 32$ m

$d_2 = v_i t + \frac{1}{2} at^2$

$= (4 \times 6) + \frac{1}{2}(4)(6)^2 = 96$ m

$d = d_1 + d_2 = 32 + 96 = 128$ m

13. ⓑ 8.2

$v_i = 72 \times \frac{5}{18} = 20$ m/s

$v_f = 13 \times \frac{5}{18} = 3.6$ m/s

$v_f = v_i + at$

[illegible]

14. ⓐ 3.6 s

$v_{iy} = v_i \sin\theta = 20 \sin(65) = 18.12$ m/s

$\therefore$ Time of flight $= \frac{-2 v_{iy}}{g} = \frac{-2(18.12)}{[illegible]}$ [illegible]

15. (a) Both objects (A) and (B)
   (b) Object (A).
16. (a) $h = v_i t + \frac{1}{2} gt^2$

$= 0 + \frac{1}{2}(10)(6)^2 = 180$ m

(b) $v_f = v_i + gt$

$= 0 + (10)(6) = 60$ m/s

Second

Answers of Test Yourself Questions

Answers of Unit One

Chapter 1 Lesson One

(1) Derived physical quantity

(2) ⓑ Meter tape, micrometer

(3) ⓓ 4.42×10^{17} s

The age of the universe in seconds

$\simeq 14 \times 10^{9} \times 365.25 \times 24 \times 60 \times 60$

$\simeq 4.42 \times 10^{17}$ s

(4) 1 ⓒ $LT^{-1}, LT^{-\frac{1}{2}}$

$x = At + B\sqrt{2t}$

$[x] = [At] + [B\sqrt{2t}]$

$L = [A]T + [B]T^{\frac{1}{2}}$

∵ The quantities which are added must have the same dimensional formula

$\therefore L = [A]T \Rightarrow [A] = LT^{-1}$

$L = [B]T^{\frac{1}{2}} \Rightarrow [B] = LT^{-\frac{1}{2}}$

2 $[P] = \frac{[F]}{[A]} = \frac{[ma]}{[A]}$

$= \frac{MLT^{-2}}{L^{2}} = ML^{-1}T^{-2}$

(5) ⓑ $t = \frac{x}{v}$

Chapter 1 Lesson Two

(1) ⓑ balance (2) is more accurate

(2) ⓒ (4 ± 0.4) m

(3) 1 ⓒ 8 %

2 $r_m = \frac{\Delta m}{m_o} = \frac{0.5}{5} = 0.1$

$r_v = \frac{\Delta v}{v_o} = \frac{0.2}{2} = 0.1$

$r_{K.E} = r_m + r_v + r_v = 0.1 + 0.1 + 0.1 = 0.3$

$(K.E)_o = \frac{1}{2} m_o v_o^2 = \frac{1}{2} \times 5 \times (2)^2 = 10$ J

$\Delta (K.E) = r_{K.E} (K.E)_o = 0.3 \times 10 = 3$ J

Chapter 2

(1) ⓒ

(2) 1 ⓑ BC, AD

2 ⓓ $\frac{1}{2}\vec{C}$

(3) ⓓ

(4) ⓓ 50 N

(5) ⓑ

(6) 1 ⓒ 147 m

2 $s_x = 3.1 \cos (180 - 155) = 2.8$ km

$s_y = 3.1 \sin (180 - 155) = 1.3$ km

(7) ⓓ 0

(8) 1 ⓓ $\vec{x} \wedge \vec{y}$

2 $|\vec{A} \wedge \vec{B}| = AB \sin \theta$

$\sin \theta = \frac{|\vec{A} \wedge \vec{B}|}{AB} = \frac{12}{3 \times 4} = 1$

$\theta = 90°$

Answers of Unit Two

Chapter 1 Lesson One

(1) 1 Periodic motion.

2 Translational motion

3 Periodic motion

(2) 1 ⓓ 90 m

$v = \frac{d}{t}$

$30 = \frac{d}{3} \Rightarrow d = 90$ m

The length of the train is 90 m

2 ⓒ

3 ⓐ

(3) 1 (1) ⓑ 50 km/h

$\because v = \frac{d}{t} = \frac{100}{2} = 50$ km/h

(2) ⓑ $\frac{10}{3}$ m/s

2 $\bar{v}_{speed} = \frac{s}{t} = \frac{10 + 5 + 10 + 5}{\frac{1}{2}} = 60$ km/h

3 The time instants at which the body's instantaneous velocity equals zero are the points at which the slope of the tangent to the curve equals zero and they are

$t_1 = 2$ s

$t_2 = 6$ s

$t_3 = 10$ s

Chapter 1 Lesson Two

1 (1) ⟶ (b) , (2) ⟶ (c) , (3) ⟶ (a)

2 1 ⓑ 0.47 s

2 (1) bc

(2) ab, de

(3) cd

Chapter 2 Lesson One

1 1 ⓐ 2700 m/s

2 $v_f = v_i + at$

$= 20 + (-2 \times 12) = -4$ m/s

After 12 s, the car's velocity will be 4 m/s to the south

2 1 ⓒ 400 m

2 ⓓ 16.4 s

3 ⓒ 2 d

4 1 From the third equation of motion:

$v_f^2 - v_i^2 = 2ad$

$(30)^2 - (20)^2 = 2 \times a \times 200$

$a = 1.25$ m/s^2

From the first equation of motion

$v_f = v_i + at$

$30 = 20 + 1.25\,t$

$t = 8$ s

2 ⓑ 50 m/s

Chapter 2 Lesson Two

1 1 ⓐ The average velocity of the body during the first second is 4.9 m/s

2 ⓓ L, M and L, M

2 1 ⓑ equal to – 30 m/s

2 ∵ The time of rising to the maximum height equals the time of falling to the ground

∴ At falling $h = v_i t + \frac{1}{2} g t^2$, $v_i = 0$

$h = \frac{1}{2} g t^2 = \frac{1}{2} \times 10 \times (3)^2 = 45$ m

Chapter 2 Lesson Three

1 (1) (i) ⓑ At the maximum height reached by the body

(ii) ⓓ They won't be parallel at any point during the motion

(2) ⓒ 2 m

(3) ⓓ 80°

(4) ⓓ d

2 $v_i = 5 v_x$

∵ $v_{ix} = v_i \cos\theta$

$v_{ix} = 5 v_{ix} \cos\theta$

$\cos\theta = \frac{1}{5}$

$\theta = 78.46°$

Chapter 3

1 ⓒ 50 N, 20 N

2 In the forward direction (in the same direction of the train motion)

3 1 ⓓ $-\vec{F}$

2 ⓓ The force of attracting the Earth by the kite

3 ⓑ force (2) > force (3)

4 ⓒ 9 N

Third

Answers of Monthly Tests

Answers of Test 1 on the 1st Month

1. ⓒ Amount of substance and time.
2. ⓐ $\sqrt{3}$
3. ⓒ 1.23×10^{4} g
4. ⓒ $\vec{F}_3$
5. ⓓ 2 atm
6. ⓐ 0.04 m
7. ⓒ 10 m in direction $A\vec{H}$
8. ∵ The measuring unit of acceleration is $m.s^{-2}$.
   ∴ Its dimensional formula is $L\,T^{-2}$
   ∴ $L^x\,T^y = L\,T^{-2}$
   ∴ $x = 1$, $y = -2$
9. $A = \sqrt{A_x^2 + A_y^2} = \sqrt{(3)^2 + (4)^2} = 5$ units
   $\tan\theta_A = \frac{4}{3}$ $\qquad \theta_A = 53.13°$
   $B = \sqrt{B_x^2 + B_y^2} = \sqrt{(6)^2 + (8)^2} = 10$ units
   $\tan\theta_B = \frac{8}{6} = \frac{4}{3}$, $\theta_B = 53.13°$
   $\theta_A = \theta_B$
   ∴ The two vectors $\vec{A}$ and $\vec{B}$ are in the same direction
   ∴ $C = A + B = 5 + 10 = 15$ units
   Another Solution:
   $C_x = A_x + B_x = 3 + 6 = 9$ units
   $C_y = A_y + B_y = 4 + 8 = 12$ units
   $C = \sqrt{C_x^2 + C_y^2} = \sqrt{(9)^2 + (12)^2} = 15$ units
10. To reduce the measuring error

Answers of Test 2 on the 1st Month

1. ⓒ Measuring the area of a room using meter tape.
2. ⓓ $ML^{-2}T^{-2}$, impossible
3. ⓑ 56.3°
4. ⓓ 24 m
5. ⓓ 2 N in the direction of $\vec{F}_1$
6. ⓑ $3\sqrt{2}$ units
7. ⓑ Pressure is a derived quantity, while electric current intensity is a fundamental quantity
8. ∵ $A_x = A\cos\theta$
   ∴ $5 = A\cos(90 - 30)$, ∴ $A = 10$ units
9. Because there might be numerical values in any of the sides of the equation, where numbers have no dimensions
10. $r_v = r_d + r_t = \frac{\Delta d}{d_o} + \frac{\Delta t}{t_o} = \frac{0.1}{10} + \frac{0.1}{5} = 0.03$
   $v_o = \frac{d_o}{t_o} = \frac{10}{5} = 2$ m/s
   $\Delta v = r_v\, v_o = 0.03 \times 2 = 0.06$ m/s
   $v = (v_o \pm \Delta v) = (2 \pm 0.06)$ m/s

Answers of Test 1 on the 2nd Month

1. ⓑ Motion of a bullet fired from a gun
2. ⓑ 2 m/s^2
3. ⓐ Student x, Student x
4. ⓑ 18 m/s
5. ⓑ $\sqrt{3}$ v
6. ⓒ 40 m
7. ⓒ The car would stop before reaching the red light by 20 m.
8. (a) $d = 0$
   $\bar{v} = \frac{d}{t} = 0$
   (b) $s = 6 + 1 + 2 + 5 + 4 = 18$ m
   $v_{speed} = \frac{s}{t} = \frac{18}{9} = 2$ m/s
9. (a) $d = v_i t + \frac{1}{2} a t^2$ $\qquad v_i = 0$
   ∴ Slope $= \frac{\Delta d}{\Delta t^2} = \frac{1}{2}$ a
   (b) $v_f^2 = v_i^2 + 2ad$ $\qquad v_i = 0$
   ∴ Slope $= \frac{\Delta v_f^2}{\Delta d} = 2$ a
10. The magnitude of acceleration of the body motion through interval AB is greater than the magnitude of acceleration of its motion through interval BC because
   Slope $= \frac{\Delta v}{\Delta t} = a$
   $Slope_{AB} > Slope_{BC}$
   $a_{AB} > a_{BC}$

Answers of Test 2 on the 2nd Month

1. ⓓ zero acceleration
2. ⓐ 3 m/s^2
3. ⓒ 1.75 minutes
4. ⓑ $\frac{1}{\sqrt{2}}$
5. ⓓ Body (A) moves with a positive acceleration while body (B) moves with a negative acceleration
6. ⓒ 40 m/s
7. ⓓ All bodies have the same average velocity
8. $v_f^2 = v_i^2 + 2\,ad$
   $0 = (20)^2 + (2 \times a \times 5 \times 10^{-2})$
   $a = -4000$ m/s^2
9. Point C
   The velocity of the body at a certain instant equals the slope of the tangent to the (d-t) curve at the same instant
   ∵ The slope of the tangent to the (d-t) curve at point C equals zero
   ∴ The body stops for an instant at point C
10. The direction of the acceleration of the car is opposite to the direction of its motion because the velocity of the car decreases as time passes where the car cuts smaller displacements through equal intervals of time as time passes

Fourth

Answers of General Exams

Answers of General Exam 1

1. (c) $3.6 \times 10^{-3}\ m^2$
2. (c) four times
3. (c) $\sqrt{3}$
4. (d) (2.8 ± 0.03) m
5. (c) $\frac{1}{9}$

$d = v_i t + \frac{1}{2} a t^2$

$d = \frac{1}{2} a t^2$

6. (d) doesn't equal zero, doesn't equal zero
7. (d) T
8. (c)
9. (c) 100 m

$d = v t$

10. $v_f^2 = v_i^2 + 2ad$

$v_f = \sqrt{v_i^2 + 2ad} = \sqrt{\ldots + (2 \times 1 \times 50)} = 10$ m/s

11. (c) Add them and dot product
12. (c) N < M < P < O
13. (a) 0
14. (b) $2\sqrt{3}$ units

∵ The resultant vector $(\vec{C})$ is perpendicular to vector $\vec{B}$

15. Answer by yourself

16. Angle θ should increase to balance the horizontal component of the force $\vec{F_1}$ with the force $\vec{F_2}$

Answers of General Exam 2

1. (b) increases
2. (c) 10 m.s^{-1}, 8 m.s
3. (c) π
4. (b) $\frac{1}{149}$
5. (d)
6. (c)
7. (a) 0.2515 s
8. (b) 1500 N
9. (d) 9 m/s

By squaring both sides

By comparing with the second equation of motion

10. positive acceleration
11.
12. doesn't change
13. (d) $F = m \frac{v^2}{r}$
14. (b) 67.5 km/h

$d = v t$

$75 \times 3 = 90 \ldots$

$v = 67.5$ km/h

15. 16. Answer by yourself

Answers of General Exam 3

1 (a) Interval AB

2 (c) Both of them reach the water surface having the same velocity

3 (b) 10^4 4 (a) direct, $\frac{1}{30}$

5 (d) the force by which the ground affects the horse

6 (a) 7 (c) 50 m

8 (a)

We can divide the (velocity-time) curve as follows:

In the first half of the curve:

The velocity of the body increases at an irregular rate

The acceleration of the body is positive and non-uniform

The slope of the tangent decreases with time

The acceleration of the body decreases with time

- At the peak of the curve:

The slope of the tangent equals zero

∴ The acceleration of the body equals zero

In the second half of the curve:

The velocity of the body decreases by irregular rate

The acceleration of the body is negative and non-uniform

The slope of the tangent increases with time

The acceleration of the body increases with time, so (a) is the correct answer

9 (b) $ML T^{-2}$ 10 (c) 25 km/h

11 (c) The two balls have the same time of flight.

12 (b) 4.12 m

13 (c) 30.91 m/s

- The acceleration of the train: [illegible]

$v^2 = v_i^2 + 2a$ [illegible]

$a = \ldots = 1.74\ m/s^2$

The final velocity of the back of the train when it passes by the worker:

$v^2 = v_i^2 + 2ad$

$v_f = \sqrt{(25)^2 + (2 \times 1.74 \times 95)} = 30.91\ m/s$

14 (b) 6.71 m/s

The time taken by the ball to fall freely to reach the surface of the Earth

$\therefore d = v_i t_1 + \frac{1}{2} g t_1^2$, $(v_i)_1 = 0$

$4 = \frac{1}{2} \times 10 \times t^2$ $t = 0.894\ s$

- The velocity v by which the ball was projected:

$d = (v_i)_2 t_2 + \frac{1}{2} g t_2^2$

$4 = \left(v \times \frac{0.894}{2}\right) + \left(\frac{1}{2} \times 10 \times \left(\frac{0.894}{2}\right)^2\right)$

$= 6.71\ m/s$

15 Answer by yourself.

Answers of General Exam 4

1 (d) 40 m/s, – 4 m/s²

2 (c) The two readings are not logical

3 (b) 4 (c) Figures (1) and (2)

5 (c) $M L T^{-1}$ 6 (d) $\frac{4}{3}$

7 (d) Car (X) moves with uniform positive acceleration while car (Y) moves with uniform velocity

8 (c) 76°

$R = \ldots$ [illegible]

$\frac{\sin\theta}{\cos\theta} = 4$ $\tan\theta = 4$ [illegible]

9 (c) (335 ± 10) m/s 10 (d) 170 s

11 (c) 45 m

12 (b) 57°

The components of the vectors $\vec{A}$ and $\vec{B}$ are positive

The two vectors $\vec{A}$ and $\vec{B}$ lie in the first quarter

- The angle made by the vector $\vec{A}$ with the horizontal axis (x):

$\tan\theta_A = \frac{A_y}{A_x} = \frac{1.6}{3.2}$ $\therefore \theta_A = 26.57°$

- The angle made by the vector $\vec{B}$ with the horizontal axis (x):

$\tan\theta_B = \frac{B_y}{B_x} = \frac{4.5}{0.5}$ $\therefore \theta_B = 83.66°$

- The angle between the two vectors $\vec{A}$ and $\vec{B}$

$\theta = \theta_B - \theta_A = 83.66 - 26.57 = 57.09° \approx 57°$

13 (c) 6.4×10^6 m

14 (c) 26.5 m/s, 18.7 m

The time taken by the ball from the moment of projection till it reaches the net:

$h = v_{iy} t + \frac{1}{2} g t^2$, $v_{iy} = 0$

$2.5 - 0.9 = 0 + \left(\frac{1}{2} \times 10 \times t^2\right)$

$t = 0.566\ s$

The velocity by which the ball was projected

$d = v_{ix} t$, $v_{ix} = v_i$

$15 = v_i \times 0.566$

$v_i = 26.5\ m/s$

The time taken by the ball from the moment of projection till it reaches the ground surface

$h = v_{iy} t + \frac{1}{2} g t^2$

$2.5 = 0 + \left(\frac{1}{2} \times 10 \times T^2\right)$

$\therefore T = 0.707\ s$

- The horizontal range of the ball

$R = v_{ix} T = 26.5 \times 0.707 = 18.7\ m$

15 **Action:** The force by which the paddle (boat) pushes water backwards

Reaction: The force by which the water pushes the paddle (boat) forward

16 Answer by yourself.

Answers of General Exam 5

1 (d) 150 m towards the west

Suppose that the east direction is the positive direction of motion

$d = v_i t + \frac{1}{2} a t^2$

$= (20 \times 15) + \left(\frac{1}{2} \times \ldots \times (15)^2\right)$

$= -150\ m$

- The body moves a displacement of 150 m towards the west after 15 s from the moment of moving with the acceleration.

2 (c) 45° 3 (c) $5.59 \times 10^5\ m/s^2$

4 (b) the displacement and velocity of runner B are greater than the displacement and velocity of runner A

5 (d) Energy and density

6 (c) (0.15 ± 0.1) m

7 (b) 8 (a) the Earth by the ball

9 (b) $\vec{a} = -\vec{b}$ 10 (b)

11 (c) $\frac{4}{1}$ 12 (c) 75.24 kg, 75.26 kg

13 (b) Will be more than 100 N

14 (b) $\frac{1}{2}$

15 Answer by yourself.

Answers of General Exam 6

1 (d) 25 m 2 (a) direct, 0.1%

3 (d) $-\vec{F}$ 4 (a)

5 (d) translational, curved path

6 (c)

7 (b) $\frac{1}{4}$

The car moves with uniform acceleration

At any second $d = \frac{1}{2} a t^2$

The ratio between the distance covered in the first second (d_1) and the distance covered in the third second ($d_3 - d_2$)

[illegible]

8 (c)

9 (c) The two balls reach the ground at the same time, where the velocity of the first ball is greater than that of the second ball

The second ball

$v_i = 0$

$h = \ldots + \frac{1}{2} g t^2 = \frac{1}{2} g t^2$

$t = \sqrt{\frac{2h}{g}}$

$v = v_i + gt = gt$

The first ball

[illegible]

$v_f = \sqrt{v_x^2 + v_y^2} = \sqrt{v^2 + g^2 t^2}$

From equations (1) and (3):

The two balls fall from the same height

The two balls reach the ground at the same time

From equations (2) and (4)

The velocity of the first ball is greater than that of the second ball

(10) (b) $\vec{A} \cdot (\vec{B} \wedge \vec{C})$

(11) (b) 2 s

(12) (b) 39.2 m/s

(13) (d) 0.78 s, 2.82 s

Assume that the positive direction of motion is upwards.

$v_f^2 = v_i^2 - 2gd = (18)^2 - (2 \times 10 \times 11)$ [illegible]

$v_f = 10.2$ m/s

$v_f = v_i - gt$

$10.2 = 18 - 10 t_1$

$\therefore t_1 = 0.78$ s

The velocity of the stone at a height of 11 m from the ground during its ascending is 10.2 m/s

The velocity of the stone at a height of 11 m from the ground during its falling is -10.2 m/s

$v_f = v_i - gt$

$-10.2 = 18 - 10 t_2$

[illegible]

(14) (a) The two vectors $\overline{A}$ and $\overline{E}$

(15), (16) Answer by yourself.

Answers of General Exam 7

(1) (d) all the previous

(2) (d) 1 : 3 : 5

$d = v_i t + \frac{1}{2} g t^2$, $v_i = 0$

[illegible]

$= (1)^2 : (2)^2 : (3)^2$ [illegible]

(3) (c) 1.5 m/s²   (4) (d)

(5) (d) LT^{-1}, LT^{-2} (6) (c) 3.5 %

(7) (d) 56.25 m   (8) (d) 9.6×10^{-2} m³

(9) (c) 600 N   (10) (c) (2.5 ± 0.025) ms

(11) (d) 4.2 m/s, 2.5 m/s   (12) (a) 0°

(13) (c) 250 m

(14) (d) 106.15 m

$\because v_{iy} = v_i \sin\theta$

$\therefore v_i = \frac{20}{\sin 37^\circ} = 33.23$ m/s

[illegible] $v_x T = v_i \cos\theta\, T$

$= 33.23 \times \cos 37 \times 4 = 106.15$ m

(15), (16) Answer by yourself.

Answers of General Exam 8

(1) (c) 10 m/s²   (2) (d) The vernier caliper

(3) (b) 2.4 m

(4) (c) Figures (1) and (4)   (5) (c) 3 m/s²

(6) (c) $kg.m^{-1}.s^{-1}$ (7) (d) 0

(8) (b) The velocity increases, but the acceleration remains constant

(9) (b) 21.6 m   (10) (a)

(11) (d) 30.46 s

$d_{car} = 110 + d_{truck}$

$\therefore \Delta d = d_{car} - d_{truck} = 110$ m

$\Delta d = v_{car} t - v_{truck} t$

$110 = \left(88 \times \frac{5}{18}\right) t - \left(75 \times \frac{5}{18}\right) t$

$t = 30.46$ s

(12) (a) (1 ± 0.0525) m/s²

$d = v_i t + \frac{1}{2} a t^2$ $v_i = 0$

$d = \frac{1}{2} a t^2$

$a = \frac{2d}{t^2} = \frac{2 \times 200}{(20)^2} = 1$ m/s²

$r_d = \frac{0.5}{200} = \frac{1}{400}$

$r_t = \frac{0.5}{20} = \frac{1}{40}$

$r_a = r_d + 2 r_t = \frac{1}{400} + \left(2 \times \frac{1}{40}\right) = 0.0525$

$\Delta a = r_a\, a = 0.0525 \times 1 = 0.0525$ m/s²

$\therefore a = (1 \pm 0.0525)$ m/s²

(13) (b) 6 %

(14) (b) 1 : 3 : 5

$\because d = v_i t + \frac{1}{2} g t^2$, $v_i = 0$

$\therefore d = \frac{1}{2} g t^2$ $\therefore d \propto t^2$

Considering that the distance covered by the body within one second is d

$= d_1 : (d_2 - d_1) : (d_3 - d_2)$

[illegible]

$= (1)^2 : \left((2)^2 - (1)^2\right) : \left((3)^2 - (2)^2\right)$

[illegible]

(15) The object makes the maximum displacement when it covers half the circular path, thus it covers a distance that equals half the length of the circumference of the circular path

$s = \frac{1}{2} \times (2\pi r) = \pi r$ (1)

From the drawing at the maximum displacement, the object covers distance of

$s = 2\pi$ (2)

From equations (1) and (2):

$\pi r = 2\pi$ $r = 2$ m $2r = 4$ m

(16) Answer by yourself.

Answers of General Exam 9

(1) (d) $\overline{A} \wedge \overline{B}$, $\overline{A} \cdot \overline{B}$

(2) (d) $R = \frac{2 v_i^2 \sin\theta \cos\theta}{g}$

(3) (d) The velocity in the horizontal dimension is constant and the acceleration in the vertical dimension is constant

(4) [illegible] 0

(5) (a) 5 m/s

$d = v_i t + \frac{1}{2} a t^2$ $v_i = 0$

$\frac{2d}{t^2} = \frac{2 \times 40}{(4)^2} =$ [illegible]

(6) (c) 50 s

$d = v_i t + \frac{1}{2} a t^2$

$d_{tunnel} + L_{train} = v_i t + \frac{1}{2} a t^2$

$\therefore (1.3 \times 10^3) + 100 = 3t + \left(\frac{1}{2} \times 1 \times t^2\right)$

$1400 = 3t + \frac{1}{2} t^2$

$\frac{1}{2} t^2 + 3t - 1400 = 0$

By using the calculator

$t = 50$ s

(7) (b) less than $F_1 + F_2$ (8) (d) AB

(9) (a) 0.5 m/s²   (10) (b) 10 m²

(11) (d) 27 m/s   (12) (a) 0.4 m/s

(13) (b) (5 ± 0.27) m/s

The object is projected horizontally

[illegible]

$v = \frac{d}{t} = \frac{50}{10} = 5$ m/s

$r_d = \frac{0.2}{50} = 0.004$

$r_t = \frac{0.5}{10} = 0.05$

$r_v = r_d + r_t = 0.004 + 0.05 = 0.054$

$\Delta v = r_v\, v = 0.054 \times 5 = 0.27$ m/s

$\therefore v = (5 \pm 0.27)$ m/s

(14) (b) 0, 10 m/s²

(15), (16) Answer by yourself.

Answers of General Exam 10

(1) (c) 5 s   (2) (b) 6 m/s

(3) (c) less than the instantaneous velocity of the object at the sixth second

The instantaneous velocity equals the slope of the tangent to the displacement-time curve which represents the motion of the object in a straight line.

The slope of the tangent of the curve at the sixth second is greater than that of the line AB

The slope of the dashed line AB is less than the instantaneous velocity of the object at the sixth second

4 (c) $\vec{K} = \vec{N}$

5 (b) 45 m

6 (d) 0

7 (d) 63.43°

8 (c) 53.13°

$R = 3h$

$\frac{2 v_x v_y}{g} = \frac{3 v_y^2}{2g}$

$2 v \cos\theta = \frac{3 v \sin\theta}{2}$

$\frac{\sin\theta}{\cos\theta} = \tan\theta = \frac{4}{3}$

9 (a) Displacement of A within t_1 < Displacement of B within t_2

10 (b) 30°

11 (b) 4 m

12 (c) (2 ± 0.3) cm

13 (d) 45.6 m

Consider the vertical direction upwards is the positive direction of motion

- Displacement of the helicopter upwards:

$d_1 = v t = 8.76 \times 3.05 = 26.718$ m

Displacement of the box downwards:

$d_2 = v_i t - \frac{1}{2} g t^2$

$= (8.76 \times 3.05) - \left(\frac{1}{2} \times 9.8 \times (3.05)^2\right)$

$= -18.864$ m

The negative sign means that the displacement of the box is downwards.

Distance between the box and the helicopter (s):

$d_1 + |d_2|$

$= 26.718 + |-18.864| =$

Another Solution:

Consider the box moves with a positive acceleration relative to the helicopter so that $v_i = 0$

$= \frac{1}{2} g t^2 = \frac{1}{2} \times 9.8 \times (3.05)^2$

14 (b) 2×10^{-6}

15, 16 **Answer by yourself.**

NOTES

Exams 2023

General Exam 1

First: Choose the correct answer

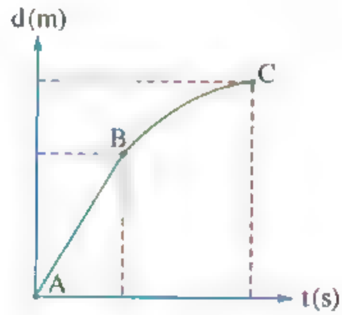
A ball of radius 1.7 cm, so its surface area equals ....
(Knowing that: The surface area of the ball = $4 \pi r^2$)

(a) 2.1×10^{-5} m^2
(b) 9.1×10^{-4} m^2
(c) 3.6×10^{-3} m^2
(d) 0.11 m^2

Two balls A and B are projected vertically upwards from the same level such that the initial velocity of ball A was double that of ball B, so the maximum height reached by ball A is ....

(a) half the maximum height reached by ball B
(b) double the maximum height reached by ball B
(c) four times the maximum height reached by ball B
(d) eight times the maximum height reached by ball B

The opposite graph represents the relation between the displacement (d) and the time (t) for an object that moves in a straight line, which of the following statements is correct?



(a) The object is at rest during the interval BC.
(b) The velocity of the object increases uniformly within the interval AB.
(c) The acceleration of the object within the interval AB is positive.
(d) The acceleration of the object within the interval BC is negative.

If A = (2 ± 0.01) m and B = (80 ± 2) cm, then the value of (A + B) equals ....

(a) (80.2 ± 2.01) m
(b) (82 ± 2.01) cm
(c) (2.8 ± 2.01) cm
(d) (2.8 ± 0.03) m

✳ Two objects started motion from rest with a uniform acceleration in a straight line for a distance d, if the time of motion of the first body is three times the time of motion of the second body, then the ratio between the acceleration of the first body to the acceleration of the second body $\left(\frac{a_1}{a_2}\right)$ is ....

(a) $\frac{1}{1}$ (b) $\frac{1}{3}$ (c) $\frac{1}{9}$ (d) $\frac{1}{81}$

A ball is projected upwards with a velocity (v_i) in a direction that makes angle (θ) with the horizontal, when the ball reaches its maximum height, ...

the resultant velocity of the ball and its acceleration equal zero

the resultant velocity of the ball equals zero and its acceleration doesn't equal zero

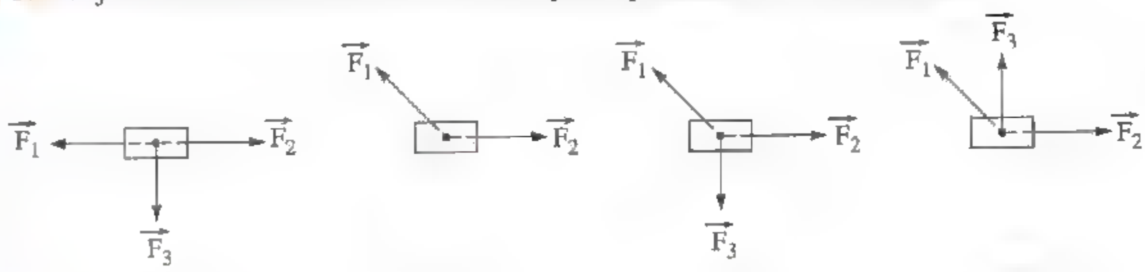
the resultant velocity of the ball doesn't equal zero and its acceleration equals zero

the resultant velocity of the ball and its acceleration don't equal zero

If the dimensional formula of the two quantities x and y is $L\,T^{-1}$ and dimensional formula of the quantity z is $L\,T^{-2}$, then the dimensional formula of the quantity k that verifies the equation: $x = y + zk$ is ....

(a) $L\,T$ (b) $L\,T^{-1}$ (c) L (d) T

The object that moves at a uniform velocity is represented by the figure ....



(a) (b) (c) (d)

✳ Two students are racing in a straight line, if the average velocity of the first student is 4 m/s and the average velocity of the second student is 5 m/s and the second student reached the end of the race before the first student by 5 seconds, then the distance of the race is ....

(a) 50 m (b) 75 m (c) 100 m (d) 150 m

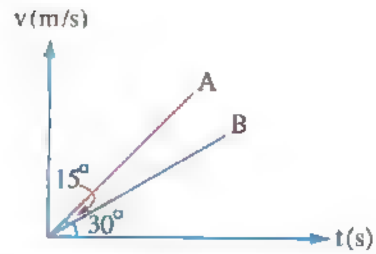
✻ An object started its motion from rest with a uniform acceleration in a straight line, if its velocity at the end of the fifth second was 5 m/s, then its average velocity when it covers 50 m equals ....

ⓐ 5 m/s ⓑ 10 m/s ⓒ 15 m/s ⓓ 20 m/s

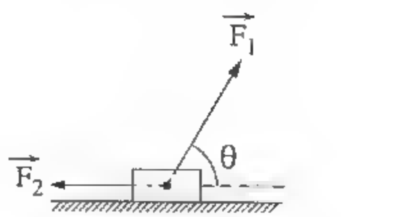
Answer the following questions

When the speed and time of motion of a car are measured, they are found to be (25 ± 0.5) m/s and (1 ± 0.01) s respectively, **calculate** the distance covered by the car during this interval.

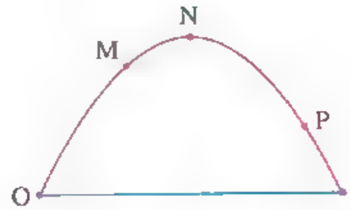
The opposite figure illustrates the relation between the velocity (v) and time (t) for two objects A and B that started their motion from rest, **calculate** the ratio between the acceleration of the two objects A and B respectively.



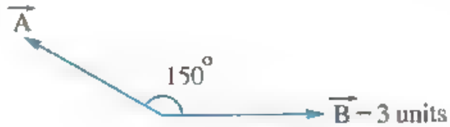
✻ The opposite figure illustrates a box that moves horizontally with a uniform velocity on a frictionless surface under the effect of two forces, if we decreased the magnitude of the force $\vec{F}_2$ while the magnitude $\vec{F}_1$ is kept constant, **what** will be the change in the angle θ that keeps the box moving with uniform velocity?



A player projects a ball upwards from point O at an angle to the horizontal and the opposite figure illustrates the path of the ball, **arrange** the points M, N and P according to the speed of the ball at each point ignoring the resistance of the air.



* In the opposite figure, if the resultant vector of the two vectors $\vec{A}$ and $\vec{B}$ is perpendicular to vector $\vec{B}$, **calculate** the value of vector $\vec{A}$.

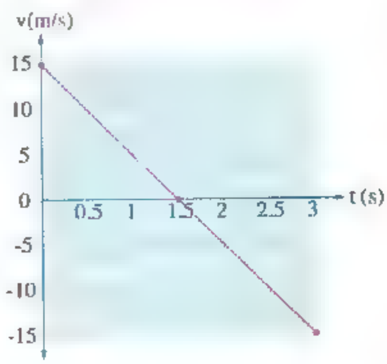


The speed of a train is decreased in a uniform rate from 96 km/h to 48 km/h through a distance of 800 m due to using the brakes, **calculate** the distance covered by the train from the moment of using the brakes till it stops if it was moving with the same acceleration.

The opposite graph illustrates the relation between the velocity of an object that is projected vertically upwards from the ground and the time, **from the graph find:**

(a) The velocity of the object at the moment when it touches the ground.

(b) The displacement of the object.



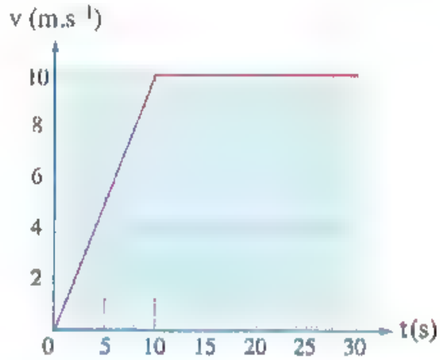
General Exam 2

First | Choose the correct answer

1. Two similar balls fell freely vertically from the top of a skyscraper such that the second ball fell 1 s later after the first ball, if we ignored the resistance of the air and observed the falling of the two balls in the Earth's gravitational field, then the distance between the balls during falling ....

   (a) remains constant (b) increases
   (c) decreases (d) equals zero

2. The opposite graph represents the change in the velocity of a girl that runs in a straight racetrack with the time. If the girl covered a displacement of 200 m within 25 s, which of the following choices is correct at the time of 25 s?



	The instantaneous velocity	The average velocity
(a)	$8\ m.s^{-1}$	$8\ m.s^{-1}$
(b)	$8\ m.s^{-1}$	$10\ m.s^{-1}$
(c)	$10\ m.s^{-1}$	$8\ m.s^{-1}$
(d)	$10\ m.s^{-1}$	$10\ m.s^{-1}$

3. If an object moved along the circumference of a circle such that its displacement after half cycle becomes 2π m, then the value of the covered distance is ....

   (a) π m (b) $\frac{\pi}{2}$ m (c) π^2 m (d) 2π m

The statement that does not express the action and the reaction forces is ....

(a) the magnitude of the action force equals the magnitude of the reaction force

(b) the action force is opposite to the reaction force in direction

(c) the action and the reaction forces act on the same object

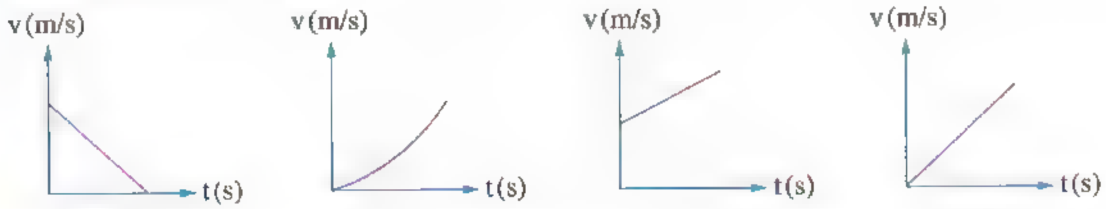
(d) the action and the reaction forces have the same nature

NASA space agency communicates with the astronauts through radio waves. If the time taken between the transmission from Earth and receiving on the Moon is 1.28 s and the speed of radio waves is 3×10^8 m/s, then the distance between the Earth and the Moon is ....

(a) 240×10^3 km (b) 384×10^3 km

(c) 480×10^3 km (d) 768×10^3 km

The (velocity-time) graph that describes the motion of a body that starts its motion with initial velocity (v_i) that doesn't equal zero and moves with uniform positive acceleration (a) during time (t) is ....



(a) (b) (c) (d)

If x = 250 ms, y = 1500 μs, then the value of (x + y) equals ....

(a) 0.2515 s (b) 4 s (c) 250.15 s (d) 1750 s

A car is moving on a horizontal road with a uniform velocity of 10 m/s and it is affected by frictional forces of 1500 N, so the force by which the engine acts on the car is ....

(a) 150 N (b) 1500 N (c) 15000 N (d) 0

✻ An object is moving with a uniform acceleration according to the relation: $t = \frac{2\sqrt{d}}{3}$, where (d) is measured in meters and (t) is measured in seconds. So, its velocity after 2 s since it started its motion is ....

(a) $\frac{4}{9}$ m/s (b) $\frac{2}{3}$ m/s (c) 4 m/s (d) 9 m/s

A car moves in a straight line with a uniform acceleration where its velocity changed from 10 m/s to 90 km/h within 20 s, so the acceleration of the car and its type are ....

- $0.75\ m/s^2$, positive acceleration
- $4\ m/s^2$, positive acceleration
- $0.75\ m/s^2$, negative acceleration
- $4\ m/s^2$, negative acceleration

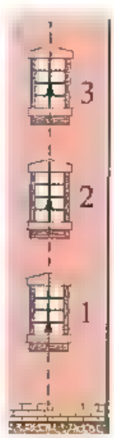
Answer the following questions

Explain the decrease in the velocity of an object that is projected vertically upwards till it vanishes.

A vector $\vec{v}$ of 16 units makes an angle of 50° with the x-axis, **calculate** the vertical and the horizontal components for this vector.

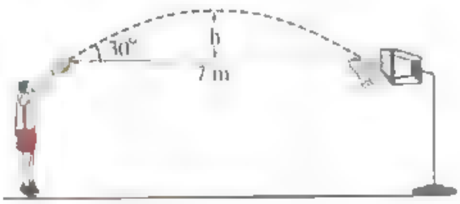
What happens if a body is projected at an angle of 75° to the horizontal, then it is projected once more with the same initial speed at an angle of 15° to the horizontal (concerning the horizontal range)?

✳ The opposite figure illustrates the path of a stone that is projected vertically upwards to pass by three similar windows that are at equal distances from each other, **arrange** these windows according to the change in the speed of the stone (Δv) during passing in front of each of them.



The opposite figure illustrates a vernier caliper used to measure the radius of a metallic cylinder.
From the figure find:
(a) The measured value for the thickness of the cylinder.
(b) The relative error for that measurement if the actual value of the radius of the cylinder is 3.68 cm.

In a basket ball match, a player threw the ball as in the opposite figure, **calculate:**
(a) The velocity by which the player should throw the ball to reach the target basket.
(b) The maximum height (h) reached by the ball from the projection level. ($g = 10\ m/s^2$)

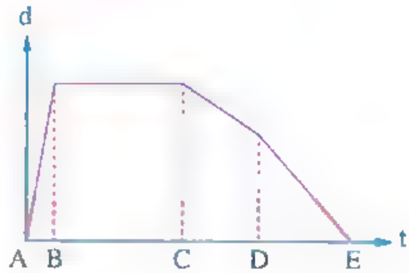


✳ A car spent three hours during its trip in a straight line. If its average velocity during the first hour was 90 km/h and its average velocity during the last two hours was v and its average velocity during the whole trip was 75 km/h, **calculate** the value of v.

General Exam 3

First Choose the correct answer

The opposite graph represents the relation between the displacement (d) and the time (t) for a car that moves in a straight line, so in which interval the velocity of the car is the greatest?



(a) Interval AB.

(b) Interval BC.

(c) Interval CD.

(d) Interval DE.

A man stands on the edge of a rocky cliff that overlooks a lake. He projects two identical balls A and B with the same speed. If A is projected upwards and B is projected downwards, so which of them will reach the water's surface at higher velocity?

(a) The ball A.

(b) The ball B.

Both of them reach the water's surface with the same speed.

(d) No correct answer.

---

cm = ... micrometer

(a) 10^2 (b) 10^4 (c) 10^6 (d) 10^8

An airport runway is designed for a particular type of airplanes, if the speed of the airplane should reach at least 126 km/h before taking off and it was moving with acceleration 3.5 m/s^2, so the length of the airport runway should be at least ....

(a) 125 m (b) 150 m (c) 175 m (d) 225 m

When a horse pulls a cart, the force which causes the movement of the horse in the forward direction is ....

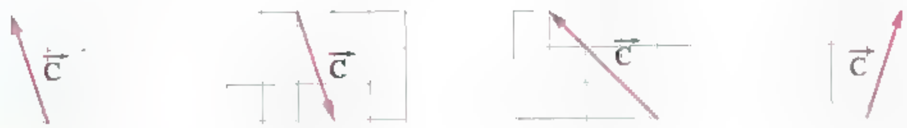
(a) the force by which the horse affects the cart

(b) the force by which the cart affects the horse

(c) the force by which the Earth affects the cart

(d) the force by which the Earth affects the horse

The opposite figure represents two vectors $\vec{X}, \vec{Y}$ from the same type, which of the following vectors represents the resultant vector $\vec{C}$ (Where: $\vec{C} = \vec{X} + \vec{Y}$)?

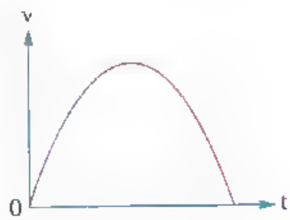


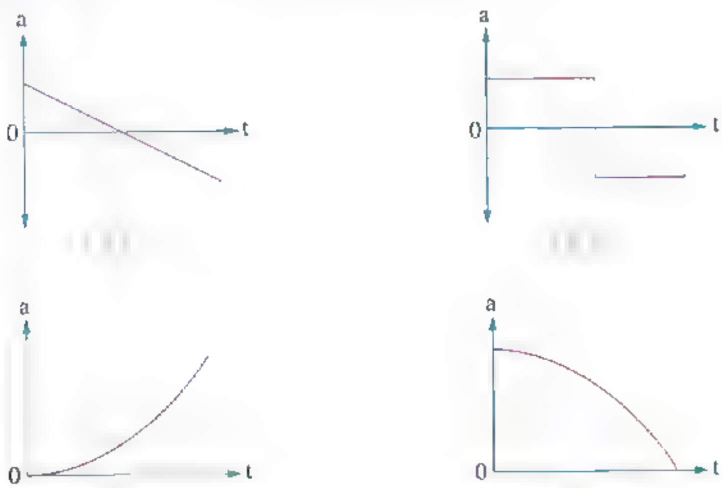
(a) (b) (c) (d)

A body is projected with velocity (v) at an angle of 30° to the horizontal and it has a horizontal range of 50 m, if the body is projected with the same velocity magnitude and at an angle of 60° to the horizontal, so its horizontal range will be ....

(a) 25 m (b) 43 m (c) 50 m (d) 100 m

✻ The opposite graph represents the change in the velocity (v) of a body that moves in a straight line with the time (t), which graph of the following graphs represents the change in the acceleration (a) of this body with the time (t)?





If the dimensional formula of the quantity (x) is LT^{-1} and the dimensional formula of the quantity (y) is ML^{-1}, so the dimensional formula of the quantity (z) that verifies the equation: $x = \sqrt{\frac{z}{y}}$ is ....

(a) MLT^{-1} (b) MLT^{-2} (c) $ML^{2}T$ (d) MLT

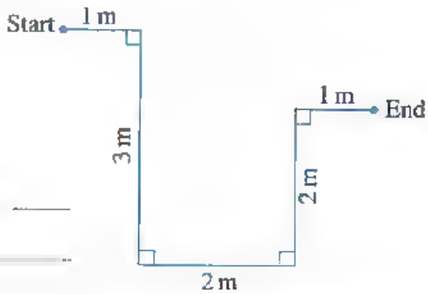
If a car covers 40 km towards the south during 1.5 h, then it changes its direction and moves 30 km towards the east during 0.5 h, so the average velocity of the car equals ....

(a) 5 km/h (b) 15 km/h (c) 25 km/h (d) 35 km/h

Second Answer the following questions

Two balls (A and B) were projected in the air, where ball (A) was projected at an angle to the horizontal greater than the angle by which the ball (B) was projected. If the maximum height reached by the two balls is the same, **which of them** has the larger time of flight? **Explain your answer.**

The opposite figure represents the path of a moving body, **calculate** the value of the total displacement covered by the body?



What happens to a group of boxes that are placed on the top of a car and are not strapped when the car starts its motion suddenly and when it stops suddenly?

When does the direction of the body's acceleration by which the body moves be opposite to the direction of its motion?

✳ A railway worker stands 180 m away from the starting point of a train whose length is 95 m which begins its motion from the rest by a uniform acceleration, if the speed of the front of the train when it passes by the worker is 25 m/s, **what** is the speed of the back of the train when it passes by the worker?

The radius of a circle is measured and it was found to be (10.5 ± 0.2) m, **calculate** the area of the circle. (Knowing that: The area of the circle $= \pi r^2$)

✳ A ball is projected vertically downwards with velocity (v) from a height of 4 m, then it reached the Earth's surface during a time that equals half the time taken by it when it is left to fall freely from the same height, **calculate** the value of (v). $(g = 10\ m/s^2)$

General Exam 4

Choose the correct answer

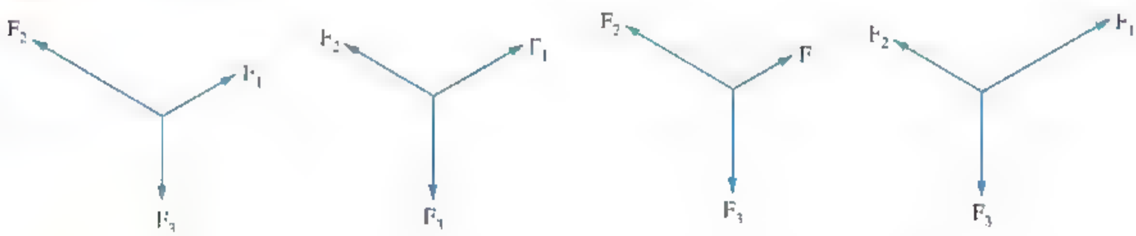
1. A body moves according to the relation; $d = 40\,t - 2\,t^2$, so its initial velocity and acceleration equal ………… , ………… respectively.

   (a) 40 m/s, -2 m/s^2 (b) 2 m/s, -40 m/s^2
   (c) 20 m/s, -1 m/s^2 (d) 40 m/s, -4 m/s^2

2. When two students measure the required time for a metallic ball to fall from the top of a building of height 5 m, the reading of the first student was 0.1 s and the reading of the second student was 10 s. Which reading is more logical?

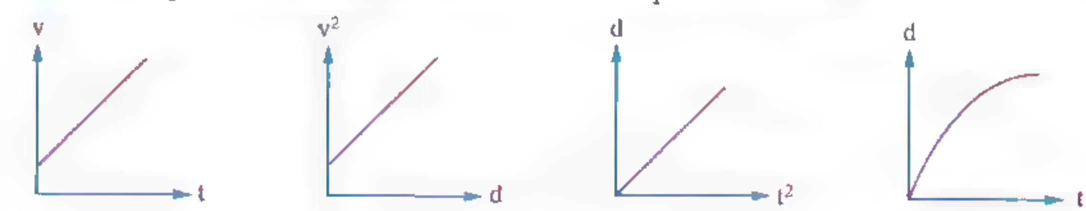
   (a) The two readings are logical.
   (b) The first reading is logical and the second reading is not logical.
   (c) The two readings are not logical.
   (d) The first reading is not logical and the second reading is logical.

3. A body moves with constant velocity under the effect of three forces $\vec{F}_1$, $\vec{F}_2$ and $\vec{F}_3$ that have equal angles between them, which of the following figures represents the forces that act on the body?



   (a) (b) (c) (d)

4. Which of the following figures represents a body that starts its motion with initial velocity that doesn't equal to zero and moves with a uniform positive acceleration?



   (1) (2) (3) (4)

   (a) Figure (1) only. (b) Figure (2) only.
   (c) Figures (1) and (2). (d) Figures (3) and (4).

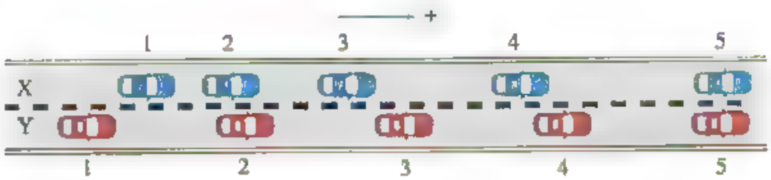
If the dimensional formula of the physical quantity (A) is $M^2 L T^{-2}$ and the dimensional formula of the physical quantity (B) is $M^2 L T^{-2}$, so the dimensional formula of the quantity (4 A – 2 B) is ....

(a) $M^4 L^2 T^{-4}$
(b) $M^{-4} L^{-2} T^4$
(c) $M^2 L T^{-2}$
(d) has no physical meaning

A car moves with a velocity of 30 m/s, its driver applies the brakes and the car is affected by a negative acceleration of 6 m/s^2, so the ratio of the velocity of the car after a period of 1 s to its velocity after a period of 2 s is ....

(a) $\frac{1}{2}$
(b) $\frac{2}{3}$
(c) $\frac{3}{2}$
(d) $\frac{4}{3}$

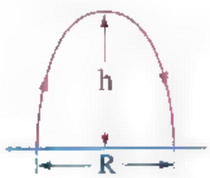
The next figure represents the positions of the two cars X and Y at consecutive intervals of time where the magnitude of each interval is 1 s and the direction of the two cars was to the right.



Which of the following statements correctly describe the motion of the two cars?

(a) The two cars move with non-uniform velocity.
(b) The car (X) moves with uniform velocity, while the car (Y) moves with uniform acceleration.
(c) The car (X) moves with negative uniform acceleration, while car (Y) moves with uniform velocity.
(d) The car (X) moves with uniform positive acceleration, while the car (Y) moves with uniform velocity.

✳ A body is projected upwards at angle (θ) to the horizontal, if the horizontal range reached by the body equals the maximum vertical height reached by it, then the value of the angle (θ) is approximately ....



(a) 45°
(b) 60°
(c) 76°
(d) 90°

A group of students measure the velocity of a moving body. which of these measurements is more accurate?

(350 ± 20) m/s (340 ± 15) m/s (335 ± 10) m/s (320 ± 10) m/s

A train was moving with uniform velocity of 108 km/h and when the driver applies the brakes, the train stops after 15 s, so the uniform acceleration by which the train moves from the moment of using the brakes is ....

(a) $-2\ m/s^2$ (b) $-1.2\ m/s^2$ (c) $-0.4\ m/s^2$ (d) $-7.2\ m/s^2$

Answer the following questions

A ball is projected vertically upwards where it took 3 s to reach the maximum height, **calculate** the maximum height reached by the ball. $(g = 10\ m/s^2)$

A man moves in a straight line away from a building for a distance of 100 m then he stops for 40 s then he completes his motion in the same direction to cover a distance of 0.5 km, **so what** is the position of the man away from the building?

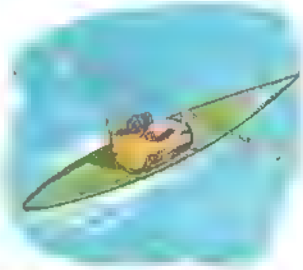
Two trucks move in two parallel lines and in two opposite directions with the same speed which equals 90 km/h, if the distance between them is 8.5 km, **when will** the two trucks meet?

"If a body moves with uniform velocity, its acceleration equals zero". **Explain**.

✱ The image illustrates a player in a boat race:

(a) **Extract** a pair of forces in this situation that represents action and reaction.

(b) **Show how** the boat can reach a greater speed.



✱ Vector $\overrightarrow{A}$ has vertical and horizontal components of 3.2 and 1.6 respectively and vector $\overrightarrow{B}$ has vertical and horizontal components of 0.5 and 4.5 respectively, **find** the angle between the two vectors $\overrightarrow{A}$ and $\overrightarrow{B}$.

17 ✱ The opposite figure shows a tennis player that hits a ball horizontally at a height of 2.5 m from the ground, **calculate:**

$(g = 10\ m/s^2)$

(a) The velocity of projecting the ball that makes it barely exceed the net that rises 0.9 m from the surface of the ground which is located away from the player at a horizontal distance of 15 m.

(b) The horizontal range of the ball if it is projected by its velocity in (a).

General Exam 5

First Choose the correct answer

1 * A boat moves towards the east with velocity of 20 m/s, then it is affected by acceleration towards the west of 4 m/s^2, so its displacement after 15 s from the moment at which the boat starts to acquire the acceleration equals ....

(a) 350 m towards the east
(b) 300 m towards the west
(c) 750 m towards the east
(d) 150 m towards the west

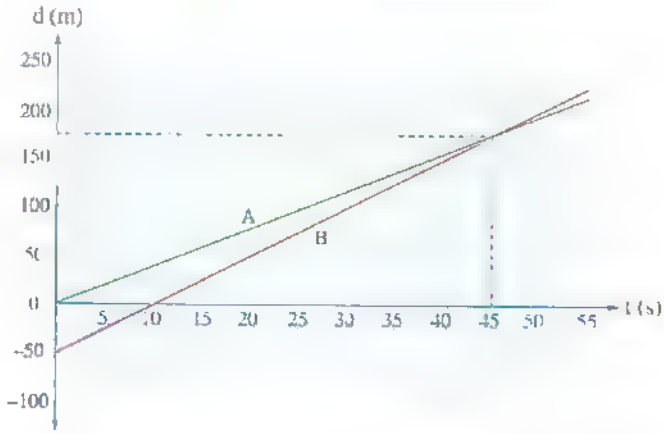
2 The scalar product of two vectors and the magnitude of their vector product equalize when the angle between the two vectors is ....

(a) 75°
(b) 60°
(c) 45°
(d) 30°

3 A bullet moves with a velocity of 220 m/s to hit a tree and penetrates it a distance of 4.33 cm until it stops, so the average acceleration of the bullet inside the tree is ....

(a) -5.59×10^3 m/s^2
(b) -3.14×10^6 m/s^2
(c) -5.59×10^5 m/s^2
(d) 2.54×10^3 m/s^2

4 The opposite graph represents the change of the positions of two runners A and B that move in a straight track in the same direction with the time. At the moment runner B passes runner A, ...



(a) the displacement and the velocity of runner B are equal to the displacement and the velocity of runner A
(b) the displacement and the velocity of runner B are greater than the displacement and the velocity of runner A
(c) the displacement and the velocity of runner B are less than the displacement and the velocity of runner A
(d) the displacement of runner B is greater than the displacement of runner A, while the velocity of runner B is equal to the velocity of runner A

✳ A man starts his motion from the rest and moves in a straight line with uniform acceleration, if his average velocity during 20 s is 2 m/s, then his instantaneous velocity after 25 s from his starting point is ....

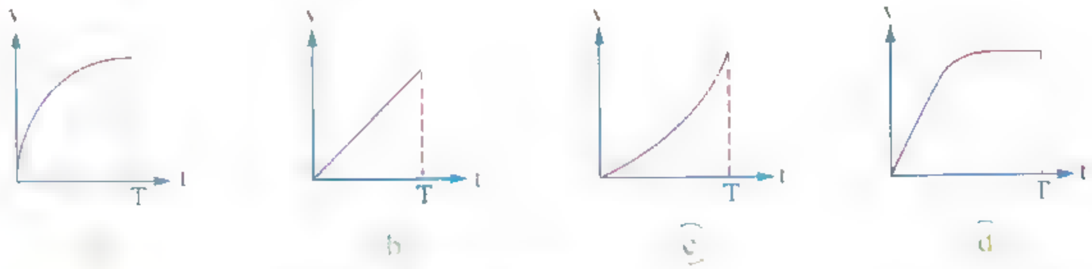
a 2.5 m/s b 5 m/s c 7.5 m/s d 10 m/s

If the height of a student is (1.8 ± 0.05) m and the height of another student is (1.95 ± 0.05) m, so the second student is longer than the first student by ....

a (3.75 ± 0.05) m b (3.75 ± 0.1) m

c (0.15 ± 0.1) m d (0.15 ± 0.05) m

A body falls freely from the top of a building and reaches the ground after time (T), if the resistance of air is neglected, which of the following figures represents the change of its velocity with time?

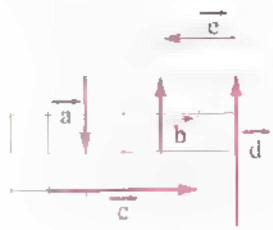


A student carries a ball in her hand if the force that acts on the ball by the Earth is the action force, so the reaction force is the force that acts on ....

a the Earth by the ball b the hand by the ball

c the ball by the hand d the hand by the Earth

From the opposite diagram, which of the following relations is correct?



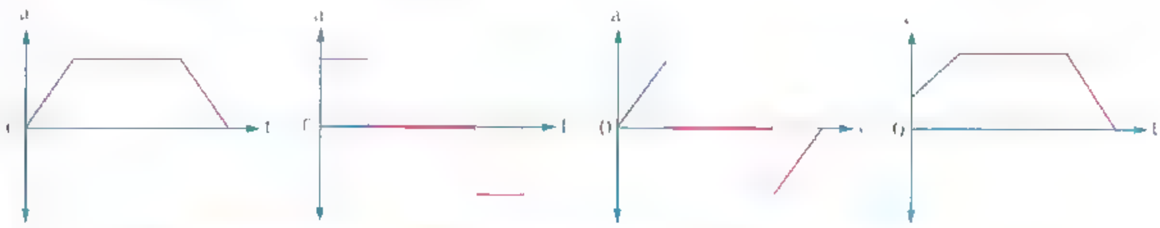
a $\vec{a} = \vec{b}$

b $\vec{a} = -\vec{b}$

c $\vec{e} = \frac{1}{2}\vec{c}$

d $\vec{a} = \frac{1}{2}\vec{d}$

A car starts its motion from rest with a uniform acceleration until its velocity reaches (v) then it continues its motion with uniform velocity for a while before the driver applies the brakes to decrease its velocity uniformly till it stops, which of the following graphs describes the motion of the car accurately?



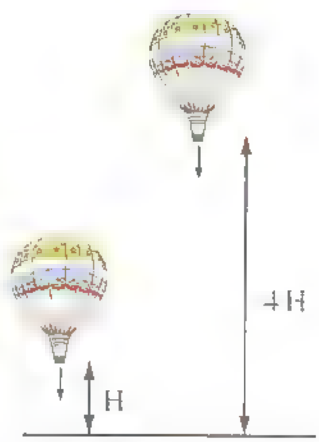
d

Answer the following questions

A group of students measured the density of a liquid several times then they calculate the average of their readings. **Explain why** the students calculate the average of their readings

If the two balls A and B rolled on the surface of smooth horizontal table with velocities v and 2 v respectively then they fall from the surface of the table at the same time, **which** of them will hit the ground first?

Two boxes are dropped from a static balloon, the first one is dropped when the distance between the balloon and the Earth's surface was (H) and the second one when the distance was (4 H), **calculate** the ratio between the time taken by the box to reach the Earth's surface in the second case and the time taken by it in the first case.



14 Two cars move on a desert road as in figure (1) and after 5 s the two cars became adjacent at the second light pole as in figure (2), if the distance between each two successive light poles is 70 m, **what** is the average velocity of the two cars A and B during the first five seconds shown in the two figures.

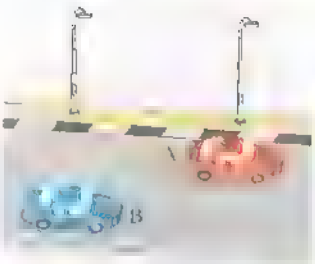


Figure (1)

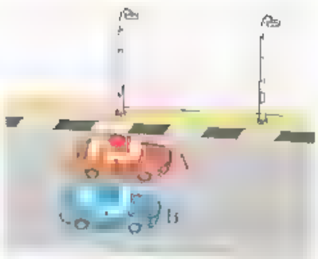


Figure (2)

15 ✻ A body is projected from the Earth's surface at angle (θ) to the horizontal where its horizontal range is 240 m and its maximum height is 45 m, **calculate** the value of (θ).

($g = 10\ m/s^2$)

In an experiment to find the speed of sound (v) in air by using closed tubes, if you know that the relation between the frequency (f) of the sound wave in the tube and the length (ℓ) of the tube is $f = \frac{1}{4} v \ell^{n}$ by neglecting the effect of the radius of the tube, **find** the value of the constant (n) using the dimensional formula knowing that the frequency is measured in hertz ($Hz = s^{-1}$).

✻ In the next two figures, there's a child of weight 200 N sitting on a swing where in figure (1) the ropes of the swing are vertical and in figure (2) the ropes of the swing are inclined:

Figure (1)

Figure (2)

Explain why the tension force in each rope is 100 N in figure (1).

(b) **Choose:**

In figure (2): What happens to the tension force (F) in each rope?

(a) Remains 100 N.

(b) Will be more than 100 N.

Will be less than 100 N.

The answer can't be determined

General Exam 6

First: Choose the correct answer

A body is moving according to the relation: $v_t = 2t$, where v_t is measured in m/s and t is measured in s. So, its displacement after 5 s from starting its motion equals .....

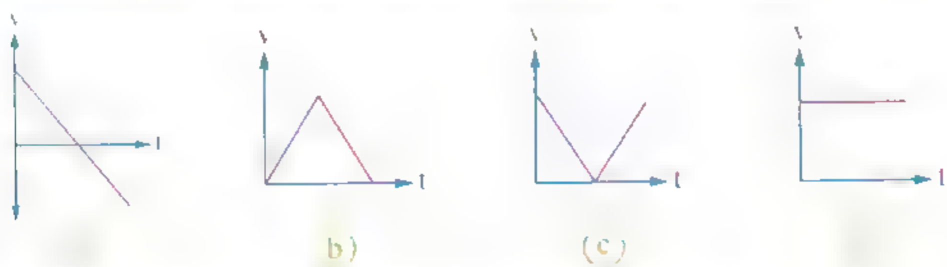
(a) 10 m (b) 15 m (c) 20 m (d) 25 m

When the density of a liquid is measured by a hydrometer, it is found to be $(10^3 + 1)$ kg/m^3. So, ...

	The type of measurement	The percentage of error in measurement
	direct	0.1 %
	direct	1 %
	indirect	0.1 %
	indirect	1 %

Which of the following bodies is in equilibrium?

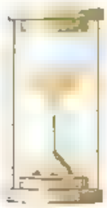
If a body is projected from the ground at angle θ to the horizontal, which graph of the following graphs represents the relation between the vertical component of the body's velocity and the time till it reaches the ground again? (Neglect the air resistance)



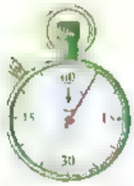
The motion of the Moon in its path around the Earth when it is observed during a whole night is considered .... motion in a ....

(a) periodic, straight line
(b) vibrational, curved path
(c) translational, straight line
(d) translational, curved path

The most accurate tool for measuring the time taken by an object to fall from the top of a building is ....


(a)

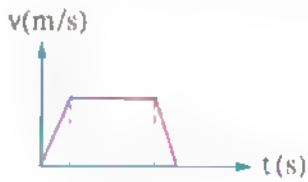

(b)

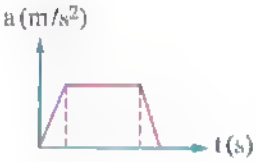

(c)

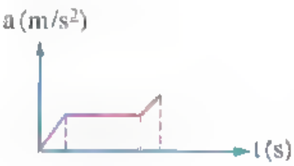
✻ A car moves from rest with uniform acceleration of 6 m/s^2, so the ratio between the distance moved by the car during the first second only and the distance moved by it during the third second only is ....

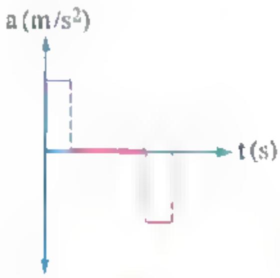
(a) $\frac{2}{3}$
(b) $\frac{1}{5}$
(c) $\frac{4}{9}$
(d) $\frac{9}{16}$

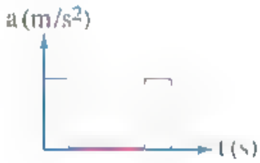
The opposite (velocity-time) graph describes the motion of a car, so the (acceleration-time) graph that represents the motion of the car is ....











✳ A ball is projected horizontally with velocity v from the roof of a building and at the same time another ball falls freely from the same height. Neglecting the air resistance, which of the following statements is right?

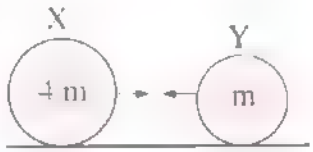
(a) The first ball reaches the ground first.

(b) The second ball reaches the ground first.

(c) The two balls reach the ground at the same time, where the velocity of the first ball is greater than that of the second ball.

(d) The two balls reach the ground at the same time, where the velocity of the second ball is greater than that of the first ball.

The opposite figure shows the collision of the two bodies X and Y which have masses of m and 4 m respectively. If the body X acts on the body Y during the collision by force $\vec{F}$, then the body Y acts on the body X by force ....



(a) $\vec{F}$ (b) $\frac{1}{4}\vec{F}$ (c) $4\vec{F}$ (d) $-\vec{F}$

Answer the following questions

Assume that the displacement (d) of a body is related with time (t) as in the given relation: $d = ct^2$

Find the dimensional formula of c.

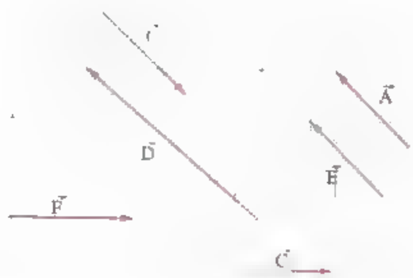
A football player kicks a ball from the ground with velocity 18 m/s at an angle of 35° to the horizontal, **calculate** the time taken by the ball to reach the ground again. ($g = 10\ m/s^2$)

A car covered a distance of 20 km in the west direction during 0.5 h, then it changes its direction to cover 20 km in the east direction during 0.5 h. **Calculate** the average speed of the car during its journey.

14. The displacement covered by a body was measured to be (6 ± 0.05) m and the time taken by the body to cover this displacement was measured to be (10 ± 0.1) s, **calculate** the average velocity of the body.

15. A rock falls freely from the top of a building of height 122.5 m. If the free fall acceleration equals $9.8\ m/s^2$, **calculate** the rock's velocity before it reaches the ground by one second.

16. Using the opposite figure, which of the following vectors are equal and which of them are unequal?



(a) The two vectors $\vec{A}$ and $\vec{E}$.

(b) The two vectors $\vec{A}$ and $\vec{C}$.

(c) The two vectors $\vec{G}$ and $\vec{F}$.

(d) The two vectors $\vec{E}$ and $\vec{D}$.

17. ✱ A stone is projected vertically upwards with velocity 18 m/s from the ground.
When will the stone reach a height of 11 m: $(g = 10\ m/s^2)$

(a) during its ascending. (b) during its falling.

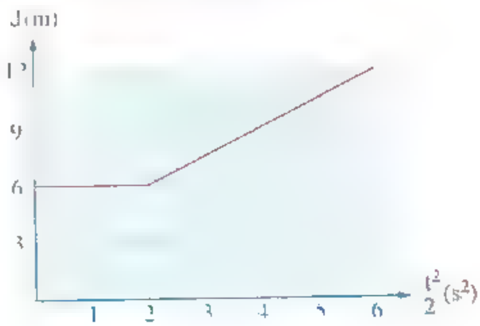
General Exam 7

Choose the correct answer

1. The body is in equilibrium when ....
   (a) the resultant of the forces that acts on it equals zero
   (b) it is static
   (c) it is moving with constant velocity in a straight line
   (d) all the previous

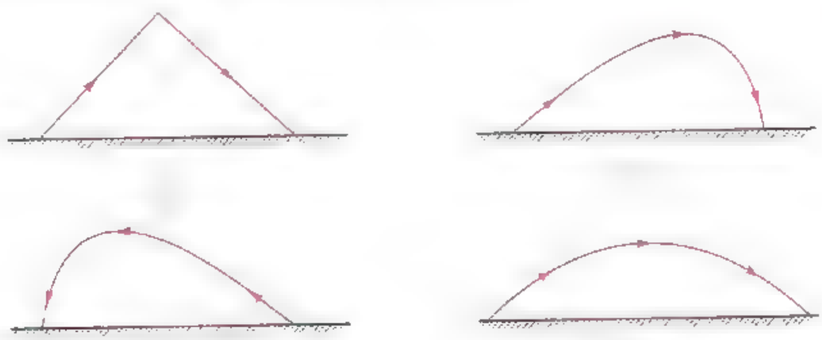
2. * When a body falls freely, the ratio between its displacement after time of 1 s and its displacement after time of 2 s and its displacement after time of 3 s is .... (Neglecting the air resistance)
   (a) 1 : 2 : 3 (b) 1 : 2 : 4 (c) 1 : 3 : 5 (d) 1 : 4 : 9

3. The opposite graph shows the $\left(d - \frac{t^2}{2}\right)$ curve for a car, so the acceleration of the car equals ....



   (a) 6 m/s^2
   (b) 2 m/s^2
   (c) 1.5 m/s^2
   (d) 3 m/s^2

4. A boy projects a rock from the ground at an angle to the horizontal, which of the following diagrams represents the motion of the rock from the point of projection till it returns to the ground? (Neglecting the air resistance)



A body moves in a straight line where its displacement (x) changes with time (t) according to this relation: $x = Bt + Ct^2$, then ....

	The dimensional formula of B	The dimensional formula of C
(a)	L	L^2
(b)	L	T^2
(c)	$L\,T^{-1}$	L^2
(d)	$L\,T^{-1}$	$L\,T^{-2}$

A stone is projected vertically upwards from the ground to reach its maximum height h after time of 3 s, so the value of h is .... ($g = 10\ m/s^2$)

(a) 60 m (b) 45 m (c) 30 m (d) 15 m

A racer accelerates his car in a straight line from rest to 180 km/h during 4 s, so it will cover a displacement of .... during 3 s.

(a) 86.45 m (b) 100 m (c) 112.5 m (d) 56.25 m

If the meter equals 3.281 feet, then the volume of a cube of side length 1.5 feet is ....

(a) $46 \times 10^{-2}\ m^3$ (b) $119.2\ m^3$
(c) $4.9\ m^3$ (d) $9.6 \times 10^{-2}\ m^3$

If the Earth acts on you when you are moving on it by an attraction force of 600 N, then your body acts on the Earth by an attraction force of .... .

(a) zero (b) 300 N (c) 600 N (d) 1200 N

The most accurate measurement of the time of motion of a body from the following measurements is ....

(a) (3 ± 0.5) ms (b) (3.2 ± 0.5) ms
(c) (2.5 ± 0.025) ms (d) (2.5 ± 0.25) ms

Second Answer the following questions

Can we apply the equations of motion with uniform acceleration on a body that moves with zero acceleration? **Explain your answer.**

Can the motion of a car be in the east direction, if the car is affected by an acceleration in the west direction at the same time? **Explain your answer.**

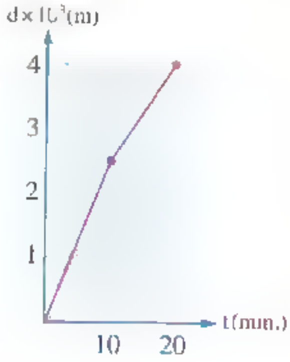
A car is moving in a straight line by a velocity of 50 m/s, at a certain instant the driver applies the brakes, so the car's velocity decreases uniformly till it reaches 30 m/s during a distance of 160 m. **Calculate** the distance covered by the car from the instant of applying the brakes till it stops.

When the density of a cube was calculated, the percentage of error in measuring its mass was 2 % and the percentage of error in measuring its side length was 0.5 %. **Calculate** the percentage of error in calculating its density $\left(\text{Knowing that: Density} = \frac{\text{Mass}}{\text{Volume}}\right)$

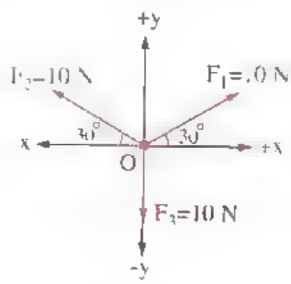
The opposite graph shows the relation between the displacement covered by a runner and the time taken by him. **Calculate** the average velocity of the runner during the following time intervals:

(a) from $t = 0$ to $t = 10$ minutes

(b) from $t = 10$ minutes to $t = 20$ minutes



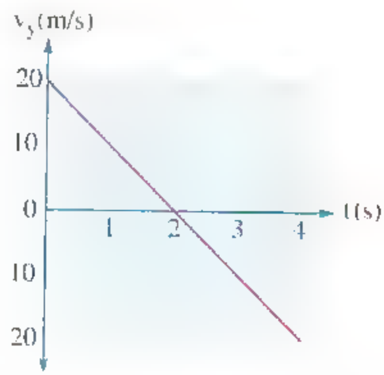
The opposite figure shows three forces acting on a particle at point O, **find** the resultant of these forces and its direction.



✻ The opposite graph shows the change of the vertical component of the velocity of a body that is projected at an angle of 37° to the horizontal with the time, **calculate:**

(a) The horizontal range of the body.

(b) The velocity of the body at a height of 15 m during its falling.



General Exam 8

Choose the correct answer

A bicycle is moving in a straight line with a positive uniform acceleration of 3 m/s^2, if it started motion with an initial velocity of 5 m/s, then after a displacement of 12.5 m its velocity becomes ....

(a) 2 m/s (b) 8 m/s (c) 10 m/s (d) 12 m/s

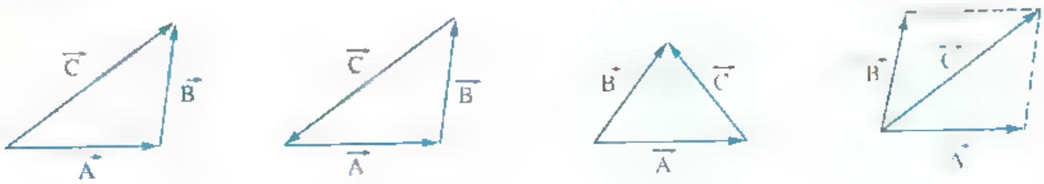
The dimensions of a metallic sheet is measured and found to be 22.3 mm, 4.35 mm and 12.7 mm, which of the following tools is used to measure them?

(a) A ruler.
(b) The standard meter.
(c) The meter tape.
(d) The vernier caliper.

✻ An object started motion from rest at a uniform acceleration in a straight line, if its average velocity within time t from starting its motion was 5 m/s, then within time 3t from starting its motion its average velocity becomes ....

(a) 5 m/s (b) 15 m/s (c) 25 m/s (d) 35 m/s

Which of the following figures represents the resultant vector $\vec{C}$ for the vectors $\vec{A}$ and $\vec{B}$?



(1) (2) (3) (4)

(a) Figures (1) and (2).
(b) Figures (3) and (4).
(c) Figures (1) and (4).
(d) Figures (2) and (3).

An object is moving in a straight line according to the relation: $v_f = \sqrt{49 + 6d}$

If v_f is measured in m/s and d is measured in m, then the object is moving with acceleration of ....

(a) 2 m/s^2 (b) $\sqrt{6}$ m/s^2 (c) 3 m/s^2 (d) 6 m/s^2

A metallic ball of radius r is dropped into a tank of water, if its velocity in water was v and it is affected by a resistance force given by the relation $F = Krv$ where K is constant, then the measuring unit of K is .... (Knowing that: $[F] = MLT^{-2}$)

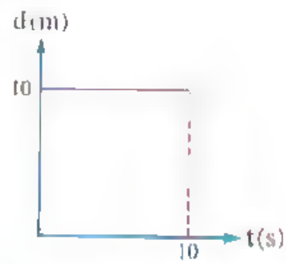
(a) $kg.m^2.s^{-1}$

(b) $kg.m^{-2}.s^{-2}$

(c) $kg.m^{-1}.s^{-1}$

(d) $kg.m.s^{-2}$

The opposite figure illustrates the (displacement-time) graph for an object of mass 2 kg, so the resultant force acting on it is ....



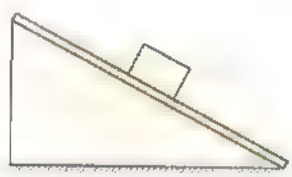
(a) 100 N

(b) 200 N

(c) 102 N

(d) 0

The opposite figure illustrates an object that slides on an inclined smooth surface, which of the following statements describes the object's motion correctly?



(a) Both velocity and acceleration increase.

(b) The velocity increases but the acceleration remains constant.

(c) The velocity remains constant and the acceleration equals zero.

(d) Both the velocity and the acceleration are constant.

An object is projected vertically upwards, so its velocity at a vertical height of $\frac{h}{4}$ was 18 m/s where h is the maximum height reached by the object, then the value of h is .... ($g = 10\ m/s^2$)

(a) 28.7 m

(b) 21.6 m

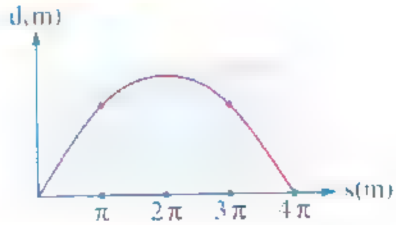
(c) 15 m

(d) 7.5 m

A bus was stopping at a traffic light when another bus collided with it suddenly from behind. Which of the following figures represents the movement of the passengers in the two buses at the moment of collision?

Answer the following questions

✻ The opposite graph represents the relation between the displacement (d) which is made by an object that is moving in a circular path from a point on its path and the distance covered by it (s). **Calculate** the diameter of the circular path.



What are the velocity and acceleration of a projectile that is projected upwards with velocity v_i at an angle θ to the horizontal when it reaches its maximum height in terms of g, θ and v_i?

✻ A car is moving in a straight line with a velocity of 88 km/h behind a truck that is moving with a velocity of 75 km/h and at a distance of 110 m from the car. **Calculate** the time required by the car to reach the truck.

A car spent three hours during its trip in a straight line. If it covered 100 km through the first two hours and 80 km through the third hour, **calculate** the average velocity of the car during this trip.

* **Prove that** the ratio between the covered distance within the first second only and the covered distance within the second second only and the covered distance within the third second only for a free falling body is (1 : 3 : 5) respectively considering the air resistance is negligible.

A ball is projected horizontally with a velocity of 6 m/s from the edge of a horizontal table at a height of 0.8 m from the ground, **calculate:**

The horizontal distance between the impact point of the ball with the ground and the edge of the table.

The velocity of impact of the ball with the ground. ($g = 10\ m/s^2$)

* An object starts its motion from rest in a straight line with a uniform acceleration (a) and it makes a displacement (d) in time (t). If $d = (200 \pm 0.5)$ m and $t = (20 \pm 0.5)$ s, **calculate** the acceleration of the object.

General Exam 9

First Choose the correct answer

1 Two vectors $\vec{A}$ and $\vec{B}$ of the same type are equal in magnitude and perpendicular on each other, then the operation that makes their product ....

	Maximum	Zero
a	$\vec{A}\,.\,\vec{B}$	$\vec{A}-\vec{B}$
b	$\vec{A}\,.\,\vec{B}$	$\vec{A}\wedge\vec{B}$
c	$\vec{A}\wedge\vec{B}$	$\vec{A}-\vec{B}$
d	$\vec{A}\wedge\vec{B}$	$\vec{A}\,.\,\vec{B}$

2 If an object is projected with a velocity v_i at an angle θ to the horizontal, then its horizontal range when it comes back to the same projection level can be calculated from the relation : ....

a) $R = \dfrac{-v_i^2 \sin\theta\cos\theta}{2g}$

b) $R = \dfrac{-v_i^2 \sin\theta\cos\theta}{g}$

c) $R = \dfrac{-2\,v_i \sin\theta\cos\theta}{g}$

d) $R = \dfrac{-2\,v_i^2 \sin\theta\cos\theta}{g}$

3 The projectiles motion is considered a motion in two dimensions, one is horizontal and the other is vertical, which of the following statements can describe the projectile's motion correctly?

a) The velocity in the horizontal dimension is variable and the acceleration in the vertical dimension is variable.

b) The velocity in the horizontal dimension is constant and the acceleration in the vertical dimension is variable.

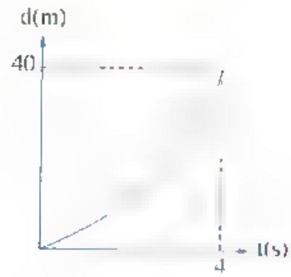
c) The velocity in the horizontal dimension is variable and the acceleration in the vertical dimension is constant.

d) The velocity in the horizontal dimension is constant and the acceleration in the vertical dimension is constant.

A man tried to push a box of mass 40 kg on a rough horizontal surface but he couldn't, so the net force acting on the box is ....
($g = 10\ m/s^2$)

(a) 0 (b) 40 N (c) 400 N (d) 4000 N

✳ The opposite graph illustrates the motion of an object that started its motion from rest with a uniform acceleration, so the acceleration of its motion is ....

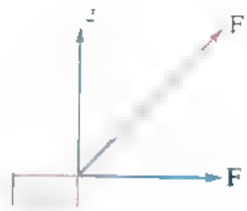


(a) $5\ m/s^2$ (b) $10\ m/s^2$
(c) $40\ m/s^2$ (d) $2.5\ m/s^2$

✳ A train of length 100 m that is moving with an acceleration of $1\ m/s^2$ entered a straight tunnel of length 1.3 km with a velocity of 3 m/s, so the required time for the entire train to get out from the tunnel is ....

(a) 300 s (b) 78 s (c) 50 s (d) 20 s

In the opposite figure, an object is acted upon by two perpendicular forces $\vec{F}_1$ and $\vec{F}_2$, so their resultant force (F) is ....



(a) equal to $F_1 + F_2$
(b) less than $F_1 + F_2$
(c) greater than $F_1 + F_2$
(d) equal to $F_1 \quad F_2$

If the two physical quantities A and B have different dimensions, which of the following mathematical operations has a physical meaning?

(a) $A + B$ (b) $A - B$ (c) $A \cdot \frac{A}{B}$ (d) AB

A man at rest started his motion in a straight line with uniform acceleration till his velocity reached 4 m/s within a time of 8 s, so the acceleration of his motion equals ....

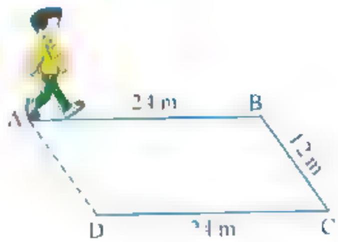
(a) $0.5\ m/s^2$ (b) $1\ m/s^2$ (c) $2\ m/s^2$ (d) $4\ m/s^2$

A student measured the dimensions of a garden of area 200 m^2, if the relative error in measuring this area was 0.05, then the absolute error for that measurement is ....

(a) 5 m^2 (b) 10 m^2 (c) 15 m^2 (d) 20 m^2

Answer the following questions

In the opposite figure a man moved from point A to point B within 10 s, then from point B to point C within 6 s, then from point C to point D within 14 s, **what** is the average velocity by which he moved from point A to point D?



A car driver saw a child in the middle of the road at a distance of 25 m from his car which was moving with a velocity of 12 m/s. He used the brakes after a response time of 0.5 s, so the car is decelerated at 6 m/s^2 till it stopped. **Does** the car hit the child or not? **Explain your answer.**

The light year is the distance covered by light within a year on Earth with a speed of 2.998×10^8 m/s. **How many** meters in the light year?

(Where the year on Earth = 365.25 days)

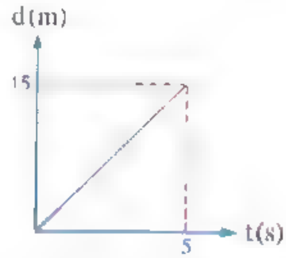
* An object is projected horizontally from the top of a building and falls down at a distance d from the base of the building within a time t, if $d = (50 \pm 0.2)$ m and $t = (10 \pm 0.5)$ s, **calculate** the initial velocity by which the object is projected.

A ball is projected vertically upwards from the surface of Earth and passed a person standing in a window at height of 28 m from the surface of Earth with a velocity of 13 m/s.
Calculate: $(g = 9.8 \text{ m/s}^2)$

(a) The initial velocity of the ball.

(b) The time required by the ball to reach the surface of Earth again.

The opposite figure represents the (displacement-time) graph for a runner moving in a straight line with a uniform velocity. **Draw** the (displacement-time) graph for the runner if he moved with a uniform velocity double his previous velocity in the same direction within the same interval of time.



An object moves according to the relation: $v_f = 10\,t$. **calculate** each of its initial velocity and acceleration. (Where: v_f is measured in m/s and t is measured in s)

General Exam 10

Choose the correct answer

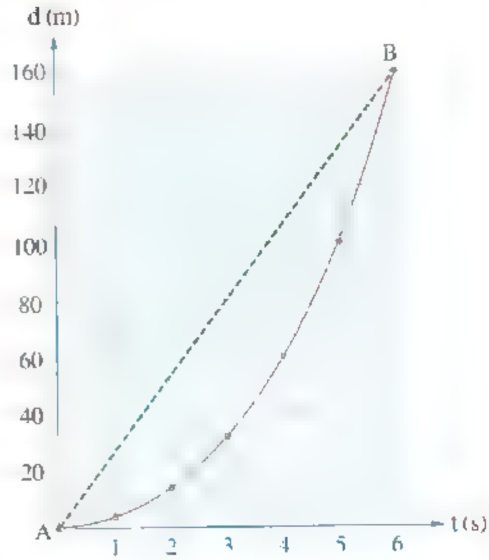
1 The time taken by a car that moves in a straight line with acceleration of 2 m/s^2, so that its velocity changes by 10 m/s is ....

(a) 0.5 s (b) 2 s (c) 5 s (d) 10 s

2 An object moved in a straight line for a distance of 100 m with a velocity of 10 m/s, then it moved on the same line for a distance of 200 m with a velocity of 5 m/s, so its average velocity through the whole trip equals ....

(a) 7.5 m/s (b) 6 m/s (c) 8 m/s (d) 30 m/s

3 ✻ The opposite figure represents the (displacement-time) graph for an object that moves in a straight line within 6 seconds, so the slope of the dashed straight line AB is ....



(a) greater than the average velocity of the object within 6 seconds

(b) less than the average velocity of the object within 6 seconds

(c) less than the instantaneous velocity of the object at the sixth second

(d) equal to the instantaneous velocity of the object at the sixth second

4 The opposite figure illustrates three vectors $\vec{K}, \vec{L}$ and $\vec{N}$, which of the following equations is incorrect?

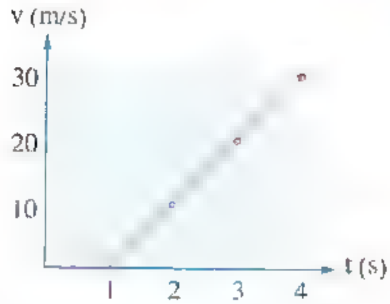
(a) $\vec{K} + \vec{N} - 0$

(b) $\vec{K} \quad \vec{N} = 2\vec{K}$

(c) $\vec{K} - \vec{N}$

(d) $\vec{K} + \vec{L} + \vec{N} - \vec{L}$

The opposite figure illustrates the (velocity-time) graph for an object, so its total displacement is ....



(a) 120 m

(b) 45 m

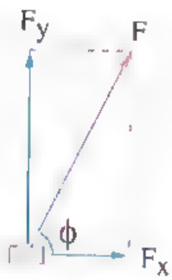
(c) 90 m

(d) 60 m

A car of mass 1000 kg moves with a uniform velocity of 12 m/s to the east, thus the resultant force acting on the car is ....

(a) 12000 N (b) 1200 N (c) 1012 N (d) 0

In the opposite figure if $F_y = 2F_x$, then the value of ϕ equals ....



(a) 60°

(b) 37.67°

(c) 45°

(d) 63.43°

A racer claims that he can accelerate his car uniformly in a straight line starting from rest to reach 180 km/h within 4 s, so he is expecting to cover 30 m from starting motion within a time of ....

(a) 12 s (b) 3.14 s (c) 2.19 s (d) 1.25 s

Two cars A and B are moving in a straight line where the velocity of A increases uniformly from 12 m/s to 18 m/s within $t_1 = 3$ s while the velocity of B increases uniformly from 10 m/s to 25 m/s within $t_2 = 10$ s. Which of the following statements is correct?

(a) Displacement of A within t_1 < Displacement of B within t_2

(b) Acceleration of B is double the acceleration of A.

(c) Acceleration of A is double the acceleration of B.

(d) Average velocity of A within t_1 > Average velocity of B within t_2

The scalar product of the two vectors $\overrightarrow{A}$ and $\overrightarrow{B}$ equals 60 units and the magnitude of their vector product equals $20\sqrt{3}$ units, thus the confined angle between the two vectors equals ....

(a) 15° (b) 30° (c) 45° (d) 75°

Answer the following questions

An object is moving according to the relation: $d = 2t^2$, **calculate** its velocity after 5 s.
(Where : d is measured in meters, t is measured in seconds)

If the acceleration of an object equals zero, **does** this mean its velocity equals zero? **Give example to your answer**.

A tiger jumps horizontally from the top of a rock of height 6.5 m above the surface of Earth with a velocity of 3.5 m/s. **Calculate** the horizontal range of the tiger's motion. ($g = 10\ m/s^2$)

If $X = (5 \pm 0.1)$ cm and $Y = (7 \pm 0.2)$ cm, **calculate** $Y - X$.

✻ If the maximum horizontal range for a projectile that is projected from the ground at an angle (θ) above the horizontal equals three times the maximum vertical height that can be reached by it, **calculate** the value of the projection angle (θ).

If the force of viscosity (F) that acts on a ball of radius r which falls in a liquid of viscosity coefficient η is given by the relation $F = 6\pi\eta rv$ where v is the uniform velocity of the ball, **find** the measuring unit of the viscosity coefficient η. (Knowing that: $[F] = MLT^{-2}$)

✻ A box has fallen from a helicopter at a very large height from the Earth's surface during its rise vertically upwards with a uniform velocity of 8.76 m/s, **calculate** the distance between the box and the helicopter after a time of 3.05 s from the moment of its falling. (Knowing that: $g = 9.8\ m/s^2$, The air resistance is neglected)

Answer of General Exam 1

First Choose the correct answer

1. (c) $3.6 \times 10^{-3}\ m^2$
2. (c) four times the maximum height reached by ball B
3. (d) The acceleration of the object within the interval BC is negative
4. (d) (2.8 ± 0.03) m
5. (c) $\frac{4}{9}$

$d = v_i t + \frac{1}{2} a t^2$ $\qquad v_i = 0$

$d = \frac{1}{2} a t^2$ $\qquad \therefore a = \frac{2d}{t^2}$

$\frac{a_1}{a_2} = \dots = \frac{4}{9}$

6. (d) the resultant velocity of the ball and its acceleration don't equal zero
7. (d) T
8. (c)
9. (c) 100 m

$d = v t$ $\qquad \therefore t = \frac{d}{v}$

$t_1 - t_2 = 5$ $\qquad \frac{d}{4} - \frac{d}{5} = 5$

$d = 100$ m

10. (a) 5 m/s

$a = \frac{v_f - v_i}{t} = \frac{5 - 0}{5} = 1\ m/s^2$

$v_f^2 = v_i^2 + 2 a d$

$v_f = \sqrt{v_i^2 + 2 a d} = \sqrt{0 + (2 \times 1 \times 50)} = 10$ m/s

$\frac{v_i + v_f}{2} = \frac{0 + 10}{2} = 5$ m/s

Second Answer the following questions

13. Angle θ should increase to balance the horizontal component of the force $\overline{F_1}$ with the force $\overline{F_2}$

15.

The resultant vector ($\overline{C}$) is perpendicular to the vector ($\overline{B}$)

$\overline{C} = \overline{A_y}$

The resultant of vectors $\overline{A}$ and $\overline{B}$ in the horizontal direction = zero

$\therefore \overline{A_x} = \overline{B}$

$A \cos 30 = 3$

$\therefore A = 2\sqrt{3}$ units

Answer of General Exam 2

First Choose the correct answer

1. (b) increases
2. (c) $10\ m.s^{-1}$, $8\ m.s^{-1}$
3. (c) π^2 m
4. (c) the action and the reaction forces act on the same object
5. (b) 384×10^3 km
6. (c)
7. (a) 0.2515 s
8. (b) 1500 N
9. (d) 9 m/s

$t = \frac{2\sqrt{d}}{3}$

By squaring both sides

$t^2 = \frac{4}{9} d$

$d = \frac{9}{4} t^2$

By comparing with the second equation of motion

$d = v_i t + \frac{1}{2} a t^2$

$v_i = 0$

$\frac{1}{2} a = \frac{9}{4}$ $\qquad a = 4.5\ m/s^2$

$v_f = v_i + at = 0 + (4.5 \times 2) = 9$ m/s

10. (a) $0.75\ m/s^2$, positive acceleration

Second Answer the following questions

14. ∵ The stone is projected vertically upwards.

It moves with a uniform acceleration that equals the acceleration due to gravity

The velocity of the stone is decreasing during its motion upwards.

∴ The time it takes during passing in front of the window increases as the height of the window increases

$\Delta v = g\,\Delta t$ $\qquad\therefore \Delta v \propto \Delta t$

- The correct order for the windows according to the change in the speed of the stone (Δv) is:
  $1 < 2 < 3$

17 $d = v\,t$

$d = d_1 + d_2$

$v\,t = v_1 t_1 + v_2 t_2$

$75 \times 3 = (90 \times$ [illegible] $) + 2\,v$

$v = 67.5$ km/h

Answer of General Exam 3

First Choose the correct answer

1 (a) Interval AB

2 (c) Both of them reach the water's surface with the same speed

3 (b) 10^4 4 (c) 175 m

5 (d) the force by which the Earth affects the horse

6 (a) 7 (c) 50 m

8 (a) We can divide the (velocity-time) curve as follows:

- In the first half of the curve:
  The velocity of the body increases at an irregular rate
  The acceleration of the body is positive and non-uniform
  The slope of the tangent decreases with time
  ∴ The acceleration of the body decreases with time
- At the peak of the curve:
  ∴ The slope of the tangent equals zero.
  The acceleration of the body equals zero
- In the second half of the curve:
  ∴ The velocity of the body decreases by irregular rate.
  The acceleration of the body is negative and non-uniform
  ∴ The slope of the tangent increases with time
  ∴ The acceleration of the body increases with time so (a) is the correct answer

9 (b) MLT^{-2} 10 (c) 25 km/h

Second Answer the following questions

15 The acceleration of the train

$v_f^2 - v_i^2 = 2\,ad$

$\therefore a = \frac{v_f^2 - v_i^2}{2\,d} = \frac{(25)^2 - 0}{2 \times 180} = 1.74\ \text{m/s}^2$

The final velocity of the back of the train when it passes by the worker:

$v_f^2 = v_i^2 + 2\,ad$

$v_f = \sqrt{(25)^2 + (2 \times 1.74 \times 95)} = 30.91$ m/s

17 - The time taken by the ball to fall freely to reach the surface of the Earth:

$d = v_i\,t_1 + \frac{1}{2}\,g t_1^2$ $\qquad (v_i)_1 = 0$

$4 = \frac{1}{2} \times 10 \times t_1^2$ $\qquad\therefore t_1 = 0.894$ s

The velocity v by which the ball was projected:

$d = (v_i)_2\,t_2 + \frac{1}{2}\,g t_2^2$

$4 = \left(v \times \frac{0.894}{2}\right) + \left(\frac{1}{2} \times 10 \times \left(\frac{0.894}{2}\right)^2\right)$

$= 6.71$ m/s

Answer of General Exam 4

First Choose the correct answer

1 (d) 40 m/s, – 4 m/s

2 (c) The two readings are not logical.

3 (b) 4 (c) Figures (1) and (2)

5 (c) M^2LT^{-2} 6 (d) $\frac{4}{3}$

7 (d) The car (X) moves with uniform positive acceleration, while the car (Y) moves with uniform velocity

8 (c) 76°

$\because R = h$

$\therefore \frac{2\,v_{ix}\,v_{iy}}{g} = \frac{v_{iy}^2}{2\,g}$

$2\,v_i \cos\theta = \frac{v_i \sin\theta}{2}$

$\frac{\sin\theta}{\cos\theta} = 4$ $\qquad \tan\theta = 4$ $\qquad \theta = 76°$

9 (c) (335 ± 10) m/s 10 (a) 2 m/s^2

Second Answer the following questions

15 (a) **Action:** The force by which the paddle (boat) pushes water backwards

Reaction: The force by which the water pushes the paddle (boat) forward

(b) By increasing the pushing force of the paddle to the water (action force), the pushing force of water to the boat increases (reaction force), according to Newton's third law ($\overline{F_1} = -\overline{F_2}$), so by increasing the pushing force of water to the boat, its velocity increases.

16 ∵ The components of the vectors $\vec{A}$ and $\vec{B}$ are positive

∴ The two vectors $\vec{A}$ and $\vec{B}$ lie in the first quarter

The angle made by the vector $\vec{A}$ with the horizontal axis (x)

$$\tan \theta_A = \frac{A_y}{A_x} = \frac{1.6}{3.2} \qquad \theta_A = 26.57°$$

- The angle made by the vector $\vec{B}$ with the horizontal axis (x)

$$\tan \theta_B = \frac{B_y}{B_x} = \frac{4.5}{0.5} \qquad \theta_B = 83.66°$$

- The angle between the two vectors $\vec{A}$ and $\vec{B}$:

$$\theta = \theta_B - \theta_A = 83.66 - 26.57 = 57.09°$$

17 (a) The time taken by the ball from the moment of projection till it reaches the net:

$$h = v_{0y} t + \frac{1}{2} g t^2 \qquad v_{0y} = 0$$

$$2.5 - 0.9 = 0 + \left(\frac{1}{2} \times 10 \times t^2\right)$$

$$\therefore t = 0.566 \text{ s}$$

- The velocity by which the ball was projected:

$$\because d = v_{0x} t \qquad , \qquad v_{0x} = v$$

$$15 = v \times 0.566$$

$$v = 26.5 \text{ m/s}$$

(b) The time taken by the ball from the moment of projection till it reaches the Earth's surface:

$$h = v_{0y} T + \frac{1}{2} g T^2$$

$$2.5 = 0 + \left(\frac{1}{2} \times 10 \times T^2\right)$$

$$T = 0.71 \text{ s}$$

- The horizontal range of the ball:

$$\therefore R = v_{0x} T = 26.5 \times 0.71 = 18.815 \text{ m}$$

Answer of General Exam 5

First Choose the correct answer

1 (d) 150 m towards the west

Suppose that the east direction is the positive direction of motion

$$d = v_i t + \frac{1}{2} a t^2$$

$$\therefore d = (20 \times 15) + \left(\frac{1}{2} \times (-4) \times (15)^2\right)$$

$$= -150 \text{ m}$$

The body moves a displacement of 150 m towards the west after 15 s from the moment of moving with the acceleration

2 (c) 45°

3 (c) 5.59×10^5 m/s^2

4 (b) the displacement and the velocity of runner B are greater than the displacement and the velocity of runner A

5 (b) 5 m/s

- During 20 s:

$$\bar{v} = \frac{v_i + v_f}{2} \qquad , \qquad v_i = 0$$

$$v_f = 2\bar{v} = 2 \times 2 = 4 \text{ m/s}$$

$$v_f = v_i + at \qquad 4 = 0 + 20 a$$

$$a = 0.2 \text{ m/s}^2$$

After 25 s

$$v_f = v_i + at \qquad = 0 + (0.2 \times 25) = 5 \text{ m/s}$$

6 (c) (0.15 ± 0.1) m

7 (b)

8 (a) the Earth by the ball

9 (b) $\vec{a} = -\vec{b}$

10 (b)

Second Answer the following questions

15 $h = \dfrac{v_{0y}^2}{2g}$

$$R = \frac{2 v_{0x} v_{0y}}{g}$$

By dividing equation (1) by equation (2)

$$\frac{h}{R} = \frac{v_{0y}^2}{2g} \times \frac{g}{2 v_{0x} v_{0y}} = \frac{v_{0y}}{4 v_{0x}}$$

$$= \frac{v_0 \sin\theta}{4 v_0 \cos\theta} = \frac{\tan\theta}{4}$$

$$\frac{45}{240} = \frac{\tan\theta}{4} \qquad \theta = 36.87°$$

17 (a) Because the child is balanced, so the resultant of the forces that acts on him should equal zero according to Newton's first law, so the tension force upwards is equal to the weight force downwards which is equal to 200 N and because the tension force upwards is distributed on the two identical vertical ropes so, the tension force on each rope equals 100 N

(b) (b) Will be more than 100 N

Answer of General Exam 6

First Choose the correct answer

1 (c) 25 m
2 (a) direct, 0.1%
3 (b)
4 (a)
5 (c) translational, curved path
6 (c)
7 (b) $\frac{1}{5}$

The car moves with uniform acceleration

During any second, $d = \frac{1}{2}at^2$

The ratio between the distance covered in the first second (d_1) and the distance covered in the third second ($d_3 - d_2$)

$$\frac{d_1}{d_3 - d_2} = \frac{\frac{1}{2}a(1)^2}{\frac{1}{2}a(3)^2 - \frac{1}{2}a(2)^2} = \frac{1}{9-4} = \frac{1}{5}$$

8 (c)

9 (c) The two balls reach the ground at the same time, where the velocity of the first ball is greater than that of the second ball

- The second ball

$v_i = 0$

$h = v_i t + \frac{1}{2}gt^2 = \frac{1}{2}gt^2$

$t = \sqrt{\frac{2h}{g}}$ (1)

$v_f = v_i + gt = gt$ (2)

- The first ball

$v_{fx} = v_x = v$, $v_{iy} = 0$, $h = \frac{1}{2}gt^2$

$t = \sqrt{\frac{2h}{g}}$ (3)

$v_{fy} = v_{iy} + gt = gt$

$v_f = \sqrt{v_{fx}^2 + v_{fy}^2} = \sqrt{v^2 + g^2t^2}$ (4)

From equations (1) and (3):

∵ The two balls fall from the same height

∴ The two balls reach the ground at the same time

From equations (2) and (4):

The velocity of the first ball is greater than that of the second ball

10 (d) $\overline{F}$

Second Answer the following questions

17 (a) Assume that the positive direction of motion is upwards

$v_f^2 = v_i^2 - 2gd = (18)^2 - 2 \times 10 \times 11$

$v_f = 10.2$ m/s

$v_f = v_i - gt$

$10.2 = 18 - 10t$

$t = 0.78$ s

(b) ∵ The velocity of the stone at a height of 11 m from the ground during its ascending is 10.2 m/s

∴ The velocity of the stone at a height of 11 m from the ground during its falling is -10.2 m/s

$v = v_i - gt$

$-10.2 = 18 - 10t_2$

∴ $t_2 = 2.82$ s

Answer of General Exam 7

First Choose the correct answer

1 (d) all the previous

2 (d) 1 : 4 : 9

$d = v_i t + \frac{1}{2}gt^2$, $v_i = 0$

$\therefore d_1 : d_2 : d_3 = t_1^2 : t_2^2 : t_3^2$

$= (1)^2 : (2)^2 : (3)^2$

$= 1 : 4 : 9$

3 (c) 1.5 m/s²
4 (d)
5 (d) [illegible]
6 (b) 45 m
7 (d) 56.25 m
8 (d) 9.6×10^{-2} m²
9 (c) 600 N
10 (c) (2.5 ± 0.025) m/s

Second Answer the following questions

17 (a) $v_y = v_i \sin\theta$

$v_i = \frac{20}{\sin 37} = 33.23$ m/s

$R = v_{ix} T = v_i \cos\theta\, T$

$= 33.23 \times \cos 37 \times 4 = 106.15$ m

(b) Slope $= a_y = \frac{\Delta v_y}{\Delta t} = \frac{0-20}{2-0} = -10$ m/s^2

$a_y = -g = -10$ m/s^2

∵ The vertical velocity during ascending equal the vertical velocity during falling at the same height from the ground

$v_{fy}^2 = v_{iy}^2 - 2gd$

$v_{fy} = \sqrt{v_{iy}^2 - 2gd}$

$= \sqrt{(20)^2 - (2 \times 10 \times 15)} = 10$ m/s

$v_{fx} = v_{ix} = v_i \cos\theta$

$= 33.23 \times \cos 37 = 26.54$ m/s

$v_f = \sqrt{v_{fx}^2 + v_{fy}^2}$

$= \sqrt{(26.54)^2 + (10)^2} = 28.36$ m/s

Answer of General Exam 8

First Choose the correct answer

1 (c) 10 m/s^2

2 (d) The vernier caliper

3 (b) 15 m/s

$v_f = v_i + at = 0 + at = at$

$\bar v = \frac{v_i + v_f}{2} = \frac{0 + v_f}{2} = \frac{v_f}{2}$

$\therefore \bar v = \frac{at}{2}$

∵ The acceleration is constant.

$\therefore \frac{v_f}{\bar v} = \frac{t_1}{t_2}$

[illegible]

4 (c) Figures (1) and (4).

5 (c) 3 m/s^2

6 (c) kg.m^{-1}.s^{-1}

7 (d) 0

8 (b) The velocity increases but the acceleration remains constant

9 (b) 21.6 m

10 (a)

Second Answer the following questions

11 The object makes the maximum displacement when it covers half the circular path, thus it covers a distance that equals half the length of the circumference of the circular path.

$s = \frac{1}{2} \times (2\pi r) = \pi r$ (1)

From the drawing at the maximum displacement, the object covers distance of:

$s = 2\pi$ (2)

From equations (1) and (2)

$\pi r = 2\pi$ ∴ $r = 2$ m ∴ $2r = 4$ m

13 $d_{car} = 110 + d_{truck}$

∵ $\Delta d = d_{car} - d_{truck} = 110$ m

$\Delta d = v_{car} t - v_{truck} t$

$110 = \left(88 \times \frac{5}{18}\right) t - \left(75 \times \frac{5}{18}\right) t$

$t = 30.46$ s

15 ∵ $d = v_i t + \frac{1}{2} g t^2$, $v_i = 0$

$\therefore d = \frac{1}{2} g t^2$ ∴ $d \propto t^2$

Considering that the distance covered by the body within one second is $\bar d$

$\therefore \bar d_1 : \bar d_2 : \bar d_3 = d_1 : (d_2 - d_1) : (d_3 - d_2)$

$= t_1^2 : (t_2^2 - t_1^2) : (t_3^2 - t_2^2)$

$= (1)^2 : \left((2)^2 - (1)^2\right) : \left((3)^2 - (2)^2\right)$

$= 1 : 3 : 5$

17 $d = v_i t + \frac{1}{2} a t^2$, $v_i = 0$

$d = \frac{1}{2} a t^2$

$a_o = \frac{2d}{t^2} = \frac{2 \times 200}{(20)^2} = 1$ m/s^2

$r_d = \frac{0.5}{200} = \frac{1}{400}$

$r_t = \frac{0.5}{20} = \frac{1}{40}$

$r_a = r_d + 2 r_t = \frac{1}{400} + \left(2 \times \frac{1}{40}\right) = 0.0525$

$\Delta a = r_a a_o = 0.0525 \times 1 = 0.0525$ m/s^2

$a = (1 \pm 0.0525)$ m/s^2

Answer of General Exam 9

First Choose the correct answer

1. (d) $\overline{A} \wedge \overline{B}$, $\overline{A}$ $\overline{B}$
2. (d) $R = \frac{2 v^2 \sin\theta \cos\theta}{g}$
3. (d) The velocity in the horizontal dimension is constant and the acceleration in the vertical dimension is constant
4. ( ) 0
5. ( ) 5 m/s²

$d = v_i t + \frac{1}{2} a t^2 \qquad v_i = 0$

$\therefore a = \frac{2d}{t^2} = \frac{2 \times 40}{4^2} = 5 \text{ m/s}^2$

6. (c) 50 s

$d = v_i t + \frac{1}{2} a t^2$

$d_{tunnel} + L_{train} = v_i t + \frac{1}{2} a t^2$

$(1.3 \times 10^3) + 100 = 3t + \left(\frac{1}{2} \times \ \times t^2\right)$

$1400 = 3t + \frac{1}{2} t^2$

$\frac{1}{2} t^2 + 3t - 1400 = 0$

By using the calculator:

$t = 50$ s

7. (b) less than $F_1 + F_2$
8. (d) AB
9. (a) 0.5 m/s²
10. (b) 10 m²

Second Answer the following questions

14. ∵ The object is projected horizontally

$v_{iy} = 0$

$\therefore v = v_x = \frac{d}{t}$

$(v_x)_0 = \frac{d_0}{t_0} = \frac{50}{10} = 5 \text{ m/s}$

$r_d = \frac{0.2}{50} = 0.004$

$r_t = \frac{0.5}{10} = 0.05$

$r = r_d + r_t = 0.004 + 0.05 = 0.054$

$\Delta v = r (v_x)_0 = 0.054 \times 5 = 0.27 \text{ m/s}$

$v_x = (5 \pm 0.27) \text{ m/s}$

Answer of General Exam 10

First Choose the correct answer

1. (c) 5 s
2. (b) 6 m/s
3. (c) less than the instantaneous velocity of the object at the sixth second

The instantaneous velocity equals the slope of the tangent to the (displacement-time) curve which represents the motion of the object in a straight line

The slope of the tangent of the curve at the sixth second is greater than that of the line AB

∴ The slope of the dashed line AB is less than the instantaneous velocity of the object at the sixth second

4. (c) $\vec{K}$ $\vec{N}$
5. (b) 45 m
6. (d) 0
7. (d) 63.43°
8. (c) 2.19 s
9. (a) Displacement of A within t_1 < Displacement of B within t_2
10. (b) 30°

Second Answer the following questions

15. $R = 3h$

$\frac{2 v_{ix} v_{iy}}{g} = \frac{3 v_{iy}^2}{2g}$

$\therefore 2 v_i \cos\theta = \frac{3 v_i \sin\theta}{2}$

$\therefore \frac{\sin\theta}{\cos\theta} = \tan\theta = \frac{4}{3} \qquad \therefore \theta = 53.13°$

17. Consider the vertical direction upwards is the positive direction of motion

- Displacement of the helicopter upwards:

$d_1 = v t = 8.76 \times 3.05 = 26.718 \text{ m}$

- Displacement of the box downwards

$d_2 = v_i t - \frac{1}{2} g t^2$

$= (8.76 \times 3.05) - \left(\frac{1}{2} \times 9.8 \times (3.05)^2\right)$

$= -18.864 \text{ m}$

The negative sign means that the displacement of the box is downwards

- Distance between the box and the helicopter (s):

$s = |d_1| + |d_2|$

$= |26.718| + |-18.864| = 45.582 \text{ m}$

Another Solution:

Consider the box moves with a positive acceleration relative to the helicopter, so that $v_i = 0$

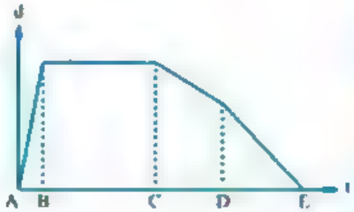
$d = \frac{1}{2} g t^2 = \frac{1}{2} \times 9.8 \times (3.05)^2 = 45.582 \text{ m}$

Model Exam 1

2022

First Multiple choice questions

1 The opposite graph represents the relation between the displacement (d) and the time (t) for a car that moves in a straight line, so in which period the velocity of the car is greatest ? ....



ⓐ Period AB
ⓑ Period BC
ⓒ Period CD
ⓓ Period DE

2 A man stands on the edge of a rocky cliff that overlooks a lake. He projects two identical balls A and B with the same velocity. If A is projected upwards and B is projected downwards, so which of them will reach the water's surface at higher velocity ? ....

ⓐ The ball A
ⓑ The ball B
ⓒ Both of them reach the water's surface with the same velocity
ⓓ No correct answer

3 cm = ... micrometer

ⓐ 10^2 ⓑ 10^4 ⓒ 10^6 ⓓ 10^8

4 An airport runway is designed for a particular type of airplanes, if the speed of the airplane should reach at least 126 km/h before taking off and it was moving with acceleration 3.5 m/s^2, so the length of the airport runway should be at least ....

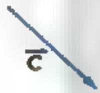
ⓐ 125 m ⓑ 150 m ⓒ 175 m ⓓ 225 m

5. When a horse pulls a cart, the force which causes the movement of the horse forward is ....

ⓐ the force by which the horse affects the cart
ⓑ the force by which the cart affects the horse
ⓒ the force by which the Earth affects the cart
ⓓ the force by which the Earth affects the horse

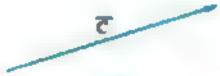
6. The opposite figure represents two vectors $\overline{X}$, $\overline{Y}$ from the same type, which of the following vectors represents the resultant vector $\overline{C}$ (where : $\overline{C} = \overline{X} + \overline{Y}$) ? ....

ⓐ



ⓑ

ⓒ

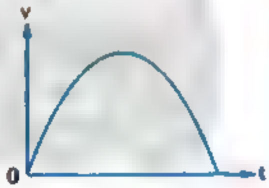


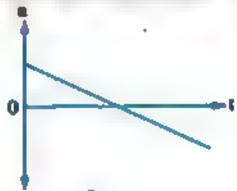
ⓓ

7. A body is projected with velocity ($\dot{v}$) at angle 30° to the horizontal and has a horizontal range of 50 m, if the body is projected with the same velocity and at angle 60° to the horizontal, so its horizontal range will be ....

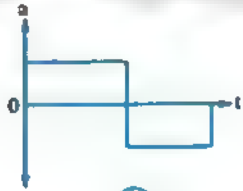
ⓐ 25 m ⓑ 43 m ⓒ 50 m ⓓ 100 m

8. The opposite graph represents the change in the velocity (v) of a body that moves in a straight line with the time (t), which graph of the following graphs represents the change in the acceleration (a) of this body with the time (t) ? ....

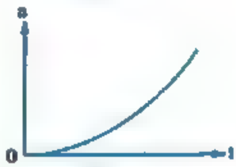




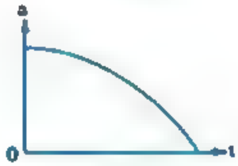
ⓐ



ⓑ



ⓒ



ⓓ

9. If the dimensional formula of the quantity (x) is LT^{-1} and the dimensional formula of the quantity (y) is ML^{-1}, so the dimensional formula of the quantity (z) that verifies the equation : $x = \sqrt{\frac{z}{y}}$ is ....

(a) MLT^{-1} (b) MLT^{-2} (c) $ML^{2}T$ (d) MLT

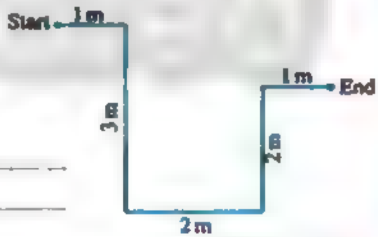
10. If a car covers 40 km towards the south during 1.5 h, then it changes its direction and moves 30 km towards the east during 0.5 h, so the average velocity of the car equals ....

(a) 5 km/h (b) 15 km/h (c) 25 km/h (d) 35 km/h

Second Answer the following questions

11. Two balls (A and B) were projected in the air, where ball (A) was projected at angle to the horizontal greater than the angle by which the ball (B) was projected. If the maximum height reached by the two balls is the same, which of them has the larger time of flight? Explain your answer.

12. The opposite figure represents the path of a moving body, calculate the value of the total displacement covered by the body ?



13. What happens to a group of boxes that are placed on the top of a car and are not strapped when the car starts its motion suddenly and stops suddenly?

(14) When does the direction of the body's acceleration by which the body moves be opposite to the direction of its motion?

(15) A railway worker stands 180 m away from the starting point of a train whose length is 95 m which begins its motion from the rest by a uniform acceleration, if the speed of the front of the train when it passes by the worker is 25 m/s, what is the speed of the back of the train when it passes by the worker ?

(16) The radius of a circle is measured and it was found to be (10.5 ± 0.2) m, calculate the area of the circle. (knowing that : the area of the circle = πr^2)

(17) A ball is projected vertically downwards with velocity (v) from a height of 4 m, then it reached the Earth's surface during a time that equals half the time taken by it when it is left to fall freely from the same height, calculate the value of (v). ($g = 10\ m/s^2$)

Model Exam 2

First Multiple choice questions

1 A body moves according to the relation $d = 40\,t - 2\,t^2$, so its initial velocity and acceleration equal .... , ... respectively.

ⓐ 40 m/s , – 2 m/s^2
ⓑ 2 m/s , – 40 m/s^2
ⓒ 20 m/s , – 1 m/s^2
ⓓ 40 m/s , – 4 m/s^2

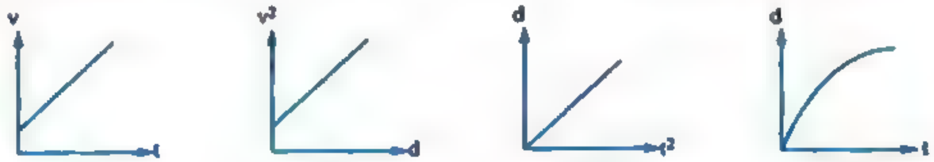
2 When measuring the volume of a liquid using a graduated cylinder, the absolute error was 0.6 cm^3 and the relative error was 1.2 % , so the actual value of volume of the liquid is ....

ⓐ 18 cm^3
ⓑ 50 cm^3
ⓒ 60 cm^3
ⓓ 120 cm^3

3 A body moves with constant velocity under the effect of three forces F_1 , F_2 and F_3 that have equal angles between them, which of the following figures represents the forces that act on the body ? ....

ⓐ ⓑ ⓒ ⓓ

4 Which of the following figures represents a body that starts its motion with initial velocity that doesn't equal to zero and moves with a uniform positive acceleration ? ....



(1) (2) (3) (4)

ⓐ Figure (1) only
ⓑ Figure (2) only
ⓒ Figures (1) and (2)
ⓓ Figures (3) and (4)

5. If the dimensional formula of the physical quantity (A) is $M^2 LT^{-2}$ and the dimensional formula of the physical quantity (B) is $M^2 LT^{-2}$, so the dimensional formula of the quantity (4 A – 2 B) is ....

ⓐ $M^4 L^2 T^{-4}$
ⓑ $M^{-4} L^{-2} T^4$
ⓒ $M^2 L T^{-2}$
ⓓ has no physical meaning

6. A car moves with velocity 30 m/s, its driver applies the brakes and the car is affected by a negative acceleration of 6 m/s^2, so the ratio between the velocity of the car after a period of 1 s to its velocity after a period of 2 s is ....

ⓐ $\frac{1}{2}$
ⓑ $\frac{2}{3}$
ⓒ $\frac{3}{2}$
ⓓ $\frac{4}{3}$

7. The next figure represents the positions of the two cars X and Y at consecutive intervals of time where the magnitude of each interval is 1 s and the direction of the two cars was to the right.

Which of the following statements correctly describe the motion of the two cars ? ....

ⓐ The two cars move with non-uniform velocity
ⓑ The car (X) moves with uniform velocity, while the car (Y) moves with uniform acceleration
ⓒ The car (X) moves with negative uniform acceleration, while car (Y) moves with uniform velocity
ⓓ The car (X) moves with uniform positive acceleration, while the car (Y) moves with uniform velocity

8. A body is projected upwards at angle (θ) to the horizontal, if the horizontal range reached by the body equals the maximum vertical height reached by it, then the value of the angle (θ) is approximately ....

ⓐ 45°
ⓑ 60°
ⓒ 76°
ⓓ 90°

9. A group of students measure the velocity of a moving body, which of these measurements is more accurate ? ....

(a) (350 ± 20) m/s (b) (340 ± 15) m/s (c) (335 ± 10) m/s (d) (320 ± 10) m/s

10. A train was moving with uniform velocity of 108 km/h and when the driver applies the brakes, the train stops after 15 s, so the uniform acceleration by which the train moves from the moment of using the brakes is ....

(a) $-2\ m/s^2$ (b) $-1.2\ m/s^2$ (c) $-0.4\ m/s^2$ (d) $-7.2\ m/s^2$

Second Answer the following questions

11. A ball is projected vertically upwards where it took 3 s to reach the maximum height, calculate the maximum height reached by the ball. ($g = 10\ m/s^2$)

12. A man moves in a straight line away from a building a distance of 100 m then he stops for 40 s then he completes his motion in the same direction to cover a distance of 0.5 km, so what is the position of the man away from the building ?

13. Two trucks move in two parallel lines and in two opposite directions with the same velocity which equals 90 km/h, if the distance between them is 8.5 km, when will the two trucks meet ?

14 "If a body moves with uniform velocity, its acceleration equals zero". Explain.

15 The image illustrates a player in a boat race :

(a) Extract a pair of forces in this situation that represents action and reaction.

(b) Show how the boat can reach a greater speed.

16 Vector A has vertical and horizontal components 3.2 and 1.6 respectively and vector B has vertical and horizontal components 0.5 and 4.5 respectively, find the angle between the two vectors $\overline{A}$ and $\overline{B}$.

17 The opposite figure shows a tennis player that hits a ball horizontally at a height of 2.5 m from the ground,

calculate : ($g = 10\ m/s^2$)

(a) The speed of projecting the ball that makes it barely exceed the net that rises 0.9 m from the surface of the ground which is located away from the player a horizontal distance of 15 m.

(b) The horizontal range of the ball if it is projected by its velocity in (a).

Model Exam 3

First Multiple choice questions

1. A boat moves towards the east with velocity of 20 m/s, then it is affected by acceleration towards the west of 4 m/s^2, so its displacement after 15 s from the moment at which the boat starts to acquire the acceleration, equals ....

   (a) 350 m towards the east.
   (b) 300 m towards the west.
   (c) 750 m towards the east.
   (d) 150 m towards the west.

2. The scalar product of two vectors and the magnitude of their vector product equalize when the angle between the two vectors is ....

   (a) 75° (b) 60° (c) 45° (d) 30°

3. A bullet moves with velocity 220 m/s to hit a tree and penetrates it a distance of 4.33 cm until it stops, so the average acceleration of the bullet inside the tree is ....

   (a) -5.59×10^3 m/s^2
   (b) -3.14×10^6 m/s^2
   (c) -5.59×10^5 m/s^2
   (d) -2.54×10^3 m/s^2

4. The opposite figure represents the relation between the velocity of a body that starts its motion from the rest and its time of motion, then the total displacement covered by the body through 45 s equals ....

   (a) 300 m (b) 350 m (c) 450 m (d) 750 m

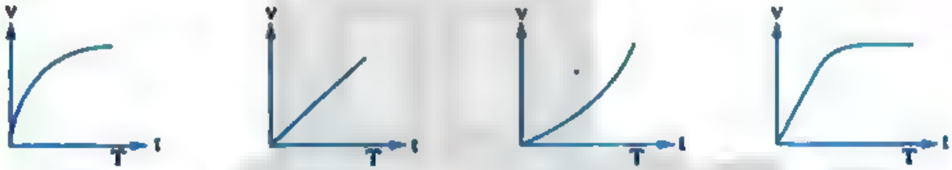
5. A man starts his motion from the rest and moves in a straight line with uniform acceleration, if his average velocity during 20 s is 2 m/s, then his instantaneous velocity after 25 s from his starting point is ....

   (a) 2.5 m/s (b) 5 m/s (c) 7.5 m/s (d) 10 m/s

6. If the length of a student is (1.8 ± 0.05) m and the length of another student is (1.95 ± 0.05) m, so the second student is longer than the first student by ....

ⓐ (3.75 ± 0.05) m ⓑ (3.75 ± 0.1) m
ⓒ (0.15 ± 0.1) m ⓓ (0.15 ± 0.05) m

7. A body falls freely from the top of a building and reached the ground after time (T), if the resistance of air is neglected, which of the following figures represents the change of its velocity with time ? ....

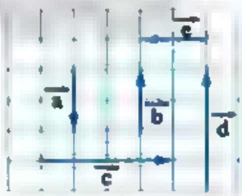


ⓐ ⓑ ⓒ ⓓ

8. A student carries a ball in her hand if the force that acts on the ball by the Earth is the action force, so the reaction force is the force that acts on ....

ⓐ the Earth by the ball. ⓑ the hand by the ball.
ⓒ the ball by the hand. ⓓ the hand by the Earth.

9. From the opposite diagram, which of the following relations is correct ? ....



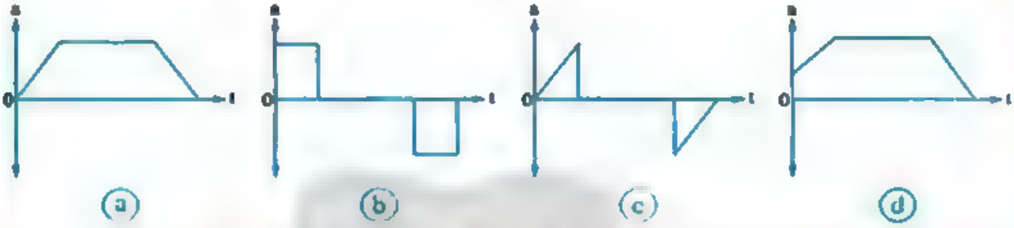
ⓐ $\vec{a} = \vec{b}$

ⓑ $\vec{a} = -\vec{b}$

ⓒ $\vec{e} = \frac{1}{2}\vec{c}$

ⓓ $\vec{a} = \frac{1}{2}\vec{d}$

10 A car starts its motion from rest and moves with uniform acceleration until its velocity reaches (v) then it continues its motion with uniform velocity for a period before the driver applies the brakes to decrease its velocity uniformly till it stops, which of the following graphs describes the motion of the car accurately ? ....



Second Answer the following questions

11 A group of students measured the density of a liquid several times then they calculate the average of their readings. Explain why the students calculate the average of their readings.

12 If the two balls A and B rolled on the surface of smooth horizontal table with velocities v and 2 v respectively then they fall from the surface of the table at the same time, which of them will hit the ground first ?

13 Two boxes are dropped from a balloon, the first one is dropped when the distance between the balloon and the Earth's surface was (H) and the second one when the distance was (4 H), calculate the ratio between the time taken by the box to reach the Earth's surface in the second case and the time taken by it in the first case.

14 Two cars move on a desert road as in figure (1) and after 5 s the two cars became adjacent at the second light pole as in figure (2), if the distance between each two successive light poles is 70 m, what is the average velocity of the two cars A and B during the first five seconds shown in the two figures.

Figure (1)

Figure (2)

15 A body is projected from the Earth's surface at angle (θ) to the horizontal where its horizontal range is 240 m and its maximum height is 45 m, calculate the value of (θ).

($g = 10\ m/s^2$)

16 In an experiment to find the velocity of sound in the air by using closed tubes, if you know that the relation between the frequency of the sound wave in the tube (f) and the length of tube (ℓ) is $f = \frac{1}{4} v \ell^n$ by neglecting the effect of the radius of the tube, find the value of the constant (n) using the dimensional formula knowing that the frequency is measured in hertz ($hz = s^{-1}$).

17 In the next two figures, there's a child sitting on a swing where in figure (1) the ropes of the swing are vertical and in figure (2) the ropes of the swing are inclined :

Figure (1)

Figure (2)

(a) Explain why the tension force in each rope is 100 N in figure (1) ?

(b) Choose :

In figure (2) : What happens to the tension force (F) in each rope ? ....

(a) Remains 100 N (b) More than 100 N (c) Less than 100 N

Model Exam 4

First Multiple choice questions

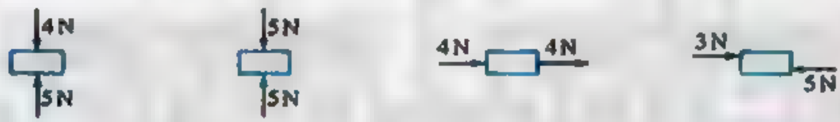
1 A body is moving according to the relation : $v_f = 2\,t$, then its displacement after 5 s equals ....

ⓐ 10 m ⓑ 15 m ⓒ 20 m ⓓ 25 m

2 When the density of a liquid is measured by a hydrometer, it is found to be $(10^3 \pm 1)\ kg/m^3$. So, ...

	The type of measurement	The percentage of error in measurement
ⓐ	Direct	0.1 %
ⓑ	Direct	1 %
ⓒ	Indirect	0.1 %
ⓓ	Indirect	1 %

3 Which of the following bodies is in equilibrium ? ....



ⓐ ⓑ ⓒ ⓓ

4 If a body is projected from the ground at angle θ to the horizontal, which graph of the following graphs represents the change of the body's vertical velocity with the time till it reaches the ground again ? .... (neglect the air resistance)

ⓐ ⓑ ⓒ ⓓ

5. The motion of the Moon in its path around the Earth when it is observed during a whole night is considered .... motion in a ....

ⓐ periodic, straight line
ⓑ vibrational, curved path
ⓒ translational, straight line
ⓓ translational, curved path

6. The most accurate tool for measuring the time taken by an object to fall from the top of a building is ....


ⓐ

ⓑ

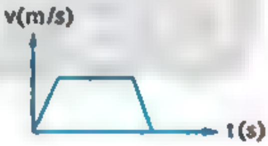
ⓒ


ⓓ

7. A car moves from rest with uniform acceleration of 6 m/s^2, so the ratio between the distance moved by the car during the first second and the distance moved by it during the third second is ....

ⓐ $\frac{2}{3}$
ⓑ $\frac{1}{5}$
ⓒ $\frac{4}{9}$
ⓓ $\frac{9}{16}$

8. The opposite (velocity - time) graph describes the motion of a car, so the (acceleration - time) graph that represents the motion of the car is ....



ⓐ


ⓑ

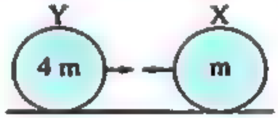

ⓒ


ⓓ

9. A ball is projected horizontally with velocity v from the roof of a building and at the same time another ball falls freely from the same height. Neglecting the air resistance, which of the following statements is right ? ....

(a) The first ball reaches the ground first
(b) The second ball reaches the ground first
(c) The two balls reach the ground at the same time, where the velocity of the first ball is greater than that of the second ball
(d) The two balls reach the ground at the same time, where the velocity of the second ball is greater than that of the first ball

10. The opposite figure shows the collision of the two bodies X and Y which have masses of m and 4 m respectively. If the body X acts on the body Y during the collision by force F, then the body Y acts on the body X by force ....



(a) F
(b) $\frac{1}{4}$ F
(c) 4 F
(d) – F

Second Answer the following questions

11. Assume that the displacement (d) of a body is related with time (t) as in the given relation : $d = ct^2$
Find the dimensional formula of c.

12. A football player kicks a ball from the ground with velocity 18 m/s at an angle of 35° to the horizontal, calculate the time taken by the ball to reach the ground again. ($g = 10$ m/s^2)

13. A car covered a distance of 20 km in the west direction during 0.5 h, then it changes its direction to cover 20 km in the east direction during 0.5 h. Calculate the average speed of the car during its journey.

14 The displacement covered by a body was measured to be (6 ± 0.05) m and the time taken by the body to cover this displacement was measured to be (10 ± 0.1) s, calculate the velocity of the body.

15 A rock falls freely from the top of a building of height 122.5 m. If the free fall acceleration equals 9.8 m/s^2, calculate the rock's velocity before it reaches the ground by one second.

16 Using the opposite figure, which of the following vectors are equal and which of them are unequal ? ....

(a) The two vectors $\overrightarrow{A}$ and $\overrightarrow{E}$

(b) The two vectors $\overrightarrow{A}$ and $\overrightarrow{C}$

(c) The two vectors $\overrightarrow{G}$ and $\overrightarrow{F}$

(d) The two vectors $\overrightarrow{E}$ and $\overrightarrow{D}$

17 A stone is projected vertically upwards with velocity 18 m/s from the ground. When will it reach a height of 11 m : ($g = 10\ m/s^2$)

(a) during its ascending.

(b) during its descending.

Model Exam 5

First Multiple choice questions

1 The body is in equilibrium when ....

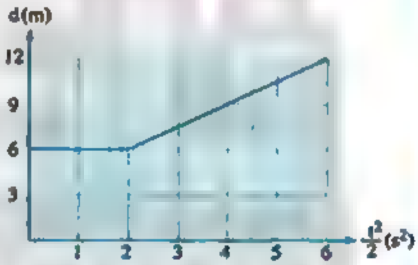
ⓐ the resultant of the forces that acts on it equals zero
ⓑ it is static
ⓒ it is moving with constant velocity in a straight line
ⓓ all the previous

2 When a body falls freely, the ratio between its displacement after time of 1 s and its displacement after time of 2 s and its displacement after time of 3 s is .... (neglecting the air resistance)

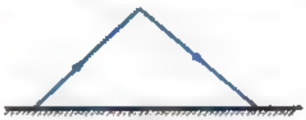
ⓐ 1 : 2 : 3 ⓑ 1 : 2 : 4 ⓒ 1 : 3 : 5 ⓓ 1 : 4 : 9

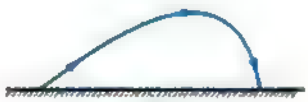
3 The opposite graph shows the $\left(d - \frac{t^2}{2}\right)$ curve for a car, so the acceleration equals ....

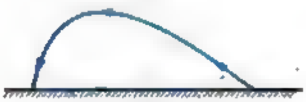
ⓐ 6 m/s^2
ⓑ 2 m/s^2
ⓒ 1.5 m/s^2
ⓓ 3 m/s^2

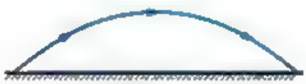


4 A boy projects a rock at angle to the horizontal, which graph of the following graphs represents the motion of the rock from the point of projection till it reaches the ground ? .... (neglecting the air resistance)


ⓐ


ⓑ


ⓒ


ⓓ

5 A body moves in a straight line where its displacement (x) changes with time (t) according to this relation : $x = Bt + Ct^2$, then ....

	The dimensional formula of B	The dimensional formula of C
a	L	L^2
b	L	T^2
c	LT^{-1}	L^2
d	LT^{-1}	LT^{-2}

6 A stone is projected vertically upwards from the ground to reach its maximum height h after time of 3 s, so the value of h is .... ($g = 10\ m/s^2$)

a 60 m
b 45 m
c 30 m
d 15 m

7 A racer accelerates his car from rest to 180 km/h during 4 s , so it will cover a displacement of .... during 3 s.

a 180 m
b 12 m
c 186.45 m
d 56.25 m

8 If the meter equals 3.281 feet, then the volume of a cube of side length 1.5 feet is ....

a $46 \times 10^{-2}\ m^3$
b $119.2\ m^3$
c $4.9\ m^3$
d $9.6 \times 10^{-2}\ m^3$

9 If the Earth acts on you when you are moving by 600 N, then your body acts on the Earth by force of ....

a zero
b 300 N
c 600 N
d 1200 N

10 The most accurate measurement of the motion time of a body from the following measurements is ....

a (3 ± 0.5) ms
b (3.2 ± 0.5) ms
c (2.5 ± 0.025) ms
d (2.5 ± 0.25) ms

Second Answer the following questions

11 Can we apply the equations of motion with uniform acceleration on a body that moves with zero acceleration ? **Explain your answer.**

12 Can the motion of a car be in the east direction, if the car is affected by an acceleration in the west direction at the same time ? **Explain your answer.**

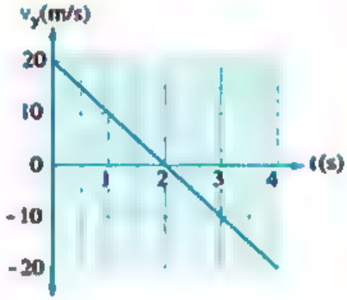
13 A car is moving by a velocity of 50 m/s, at a certain instant the driver applies the brakes, so the car's velocity decreases till it reaches 30 m/s during a distance of 160 m. If the deceleration of the car was uniform, calculate the distance covered by the car from the instant of applying the brakes till it stops.

14 When the density of a cube was calculated, the percentage of error in measuring its mass was 2 % and the percentage of error in measuring its side length was 0.5 %. **Calculate** the percentage of error in calculating its density. $\left(\text{knowing that : Density} = \frac{\text{Mass}}{\text{Volume}}\right)$

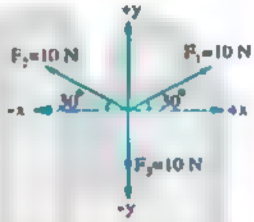
15 The opposite graph shows the change of the vertical component of the velocity of a body that is projected at an angle of 37° to the horizontal with the time, calculate :

(a) The horizontal range of the body.

(b) The velocity of the body at height of 15 m during its descending.



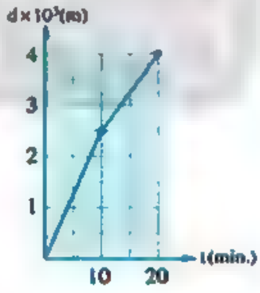
16 The opposite figure shows three forces acting on a particle, find the resultant of these forces and its direction.



17 The opposite graph shows the relation between the displacement covered by a runner and the time taken by him. Calculate the average velocity of the runner during the following time intervals :

(a) From t = 0 to t = 10 minutes

(b) From t = 10 to t = 20 minutes



Model Exam 6

First Multiple choice questions

1. A bicycle is moving with a positive uniform acceleration of 3 m/s^2, if it started motion with an initial velocity of 5 m/s, then after a displacement of 12.5 m its velocity becomes ....

ⓐ 2 m/s ⓑ 8 m/s ⓒ 10 m/s ⓓ 12 m/s

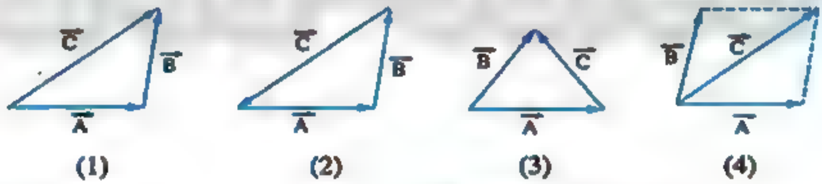
2. The dimensions of a metallic medal is measured and found to be 22.3 mm, 4.35 mm and 12.7 mm, which of the following tools is used to measure them ? ....

ⓐ A plastic ruler ⓑ The standard meter
ⓒ The meter tape ⓓ The vernier caliper

3. An object started motion from rest at a uniform acceleration, if its average velocity within time t was 5 m/s, then within time 3 t its velocity becomes ....

ⓐ 5 m/s ⓑ 15 m/s ⓒ 25 m/s ⓓ 35 m/s

4. Which of the following figures represents the resultant vector $\vec{C}$ for the vectors $\vec{A}$ and $\vec{B}$? ....



ⓐ Figures (1) and (2) ⓑ Figures (3) and (4)
ⓒ Figures (1) and (4) ⓓ Figures (2) and (3)

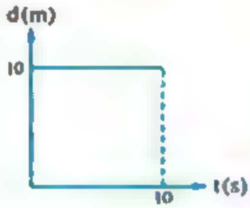
5. An object is moving in a straight line according to the relation : $v_f = \sqrt{49 + 6d}$, then the object is moving with acceleration of ....

ⓐ 2 m/s^2 ⓑ $\sqrt{6}$ m/s^2 ⓒ 3 m/s^2 ⓓ 6 m/s^2

6 A metallic ball of radius r is dropped into a tank of water, if its velocity in water was v and affected by a resistance force given by the relation F = Krv where K is constant, then the measuring unit of K is ....

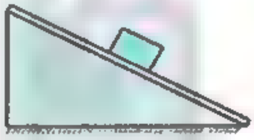
(a) $kg.m^2.s^{-1}$ (b) $kg.m^{-2}.s^{-2}$ (c) $kg.m^{-1}.s^{-1}$ (d) $kg.m.s^{-2}$

7 The opposite figure illustrates the (displacement - time) graph for an object of mass 2 kg, so the resultant force acting on it is ....



(a) 100 N (b) 200 N
(c) 102 N (d) 0

8 The opposite figure illustrates an object that slides on an inclined smooth surface, which of the following statements describes the objects motion correctly ? ....

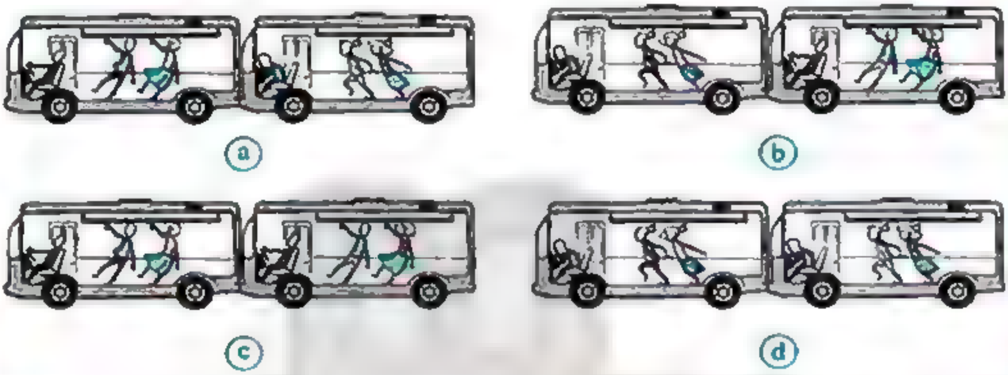


(a) Both velocity and acceleration increase
(b) The velocity increases but the acceleration remains constant
(c) The velocity remains constant and the acceleration equals zero
(d) Both the velocity and the acceleration are constant

9 An object is projected vertically upwards, so its velocity at a vertical height of $\frac{h}{4}$ was 18 m/s where h is the maximum height reached by the object, then the value of h is .... ($g = 10\ m/s^2$)

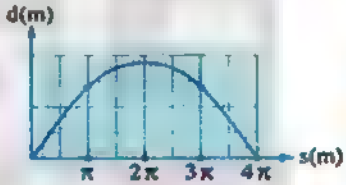
(a) 28.7 m (b) 21.6 m (c) 15 m (d) 7.5 m

(10) A bus was standing in a traffic light when another bus collided it suddenly from behind. Which of the following figures represents the movement of the passengers in the two buses at the moment of collision ? ....



Second Answer the following questions

(11) The opposite graph represents the relation between the displacement (d) which is made by an object that is moving in a circular path from a point on its path and the distance covered by it (s). Calculate the diameter of the circular path.



(12) What are the velocity and acceleration of a projectile that is projected upwards with velocity v_i at an angle θ to the horizontal when it reaches its maximum height ?

(13) A car is moving with a speed of 88 km/h behind a truck that is moving with a velocity of 75 km/h and at a distance of 110 m from the car. Calculate the time required by the car to reach the truck.

14. A car spent three hours during its trip in a straight line. If it covered 100 km through the first two hours and 80 km through the third hour, calculate the average velocity of the car during this trip.

15. Prove that the ratio between the covered distance within the first second and the covered distance within the second second and the covered distance within the third second for a free falling body is (1 : 3 : 5) respectively considering the air resistance is negligible.

16. A ball is projected horizontally with a speed of 6 m/s from the edge of a horizontal table at a height of 0.8 from the ground, calculate :

(a) The distance between the impact point of the ball with the ground and the edge of the table.

(b) The speed of impact of the ball with the ground. $(g = 10\ m/s^2)$

17. An object starts its motion from rest in a straight line with a uniform acceleration (a) and makes a displacement (d) in time (t). If $d = (200 \pm 0.5)$ m and $t = (20 \pm 0.5)$ s, calculate the acceleration of the object.

Model Exam 7

First Multiple choice questions

1. Two vectors $\overline{A}$ and $\overline{B}$ are equal in magnitude and perpendicular on each other, then the operation that makes their product ....

	Maximum	Zero
ⓐ	$\overline{A} . \overline{B}$	$\overline{A} - \overline{B}$
ⓑ	$\overline{A} . \overline{B}$	$\overline{A} \wedge \overline{B}$
ⓒ	$\overline{A} \wedge \overline{B}$	$\overline{A} - \overline{B}$
ⓓ	$\overline{A} \wedge \overline{B}$	$\overline{A} . \overline{B}$

2. If an object is projected with a velocity v_i at an angle θ to the horizontal, then its horizontal range when it comes back to the same projection plane can be calculated from the relation : ....

ⓐ $R = \frac{-v_i^2 \sin\theta \cos\theta}{2g}$

ⓑ $R = \frac{-v_i^2 \sin\theta \cos\theta}{g}$

ⓒ $R = \frac{-2 v_i \sin\theta \cos\theta}{g}$

ⓓ $R = \frac{-2 v_i^2 \sin\theta \cos\theta}{g}$

3. The projectiles motion is considered a motion in two dimensions, one is horizontal and the other is vertical, which of the following statements can describe the projectile's motion correctly ? ....

ⓐ The speed in the horizontal dimension is variable and the acceleration in the vertical dimension is variable

ⓑ The speed in the horizontal dimension is constant and the acceleration in the vertical dimension is variable

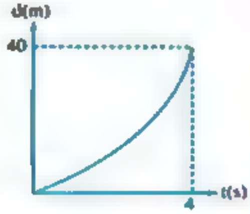
ⓒ The speed in the horizontal dimension is variable and the acceleration in the vertical dimension is constant

ⓓ The speed in the horizontal dimension is constant and the acceleration in the vertical dimension is constant

4 A man tried to push a box of mass 40 kg on a rough horizontal surface but he couldn't, so the net force acting on the box is ....

ⓐ 0 ⓑ 40 N ⓒ 400 N ⓓ 4000 N

5 The opposite graph illustrates the motion of an object started its motion from rest with a uniform acceleration, so the acceleration of its motion is ....



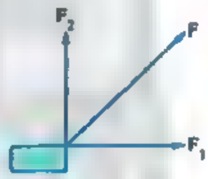
ⓐ 5 m/s^2 ⓑ 10 m/s^2

ⓒ 40 m/s^2 ⓓ 2.5 m/s^2

6 A train of length 100 m is moving with an acceleration of 1 m/s^2 entered a straight tunnel of length 1.3 km with a speed of 3 m/s, so the required time for the entire train to get out from the tunnel is ....

ⓐ 300 s ⓑ 75 s ⓒ 50 s ⓓ 20 s

7 In the opposite figure, an object is acted upon by two perpendicular forces F_1 and F_2, so their resultant force (F) is ....



ⓐ equal to $F_1 + F_2$

ⓑ less than $F_1 + F_2$

ⓒ greater than $F_1 + F_2$

ⓓ equal to $F_1 - F_2$

8 If the two physical quantities A and B have different dimensional formula, which of the following mathematical operations has a physical meaning ? ....

ⓐ $A + B$ ⓑ $A - B$ ⓒ $A - \frac{A}{B}$ ⓓ AB

9 A man at rest started his motion in a straight line till his velocity reached 4 m/s within a time of 8 s, so the acceleration of his motion equals ....

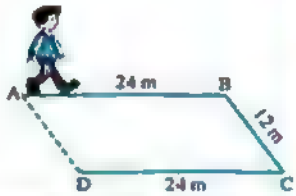
ⓐ 0.5 m/s^2 ⓑ 1 m/s^2 ⓒ 2 m/s^2 ⓓ 4 m/s^2

10 A student measured the dimensions of a garden of area 200 m^2, if the relative error in measuring this area was 0.05, then the absolute error for that measurement is ....

(a) 5 m^2 (b) 10 m^2 (c) 15 m^2 (d) 20 m^2

Second Answer the following questions

11 In the opposite figure a man moved from point A to point B within 10 s, then from B to C within 6 s, then from C to D within 14 s, what is the velocity by which he moved from point A to point D ?



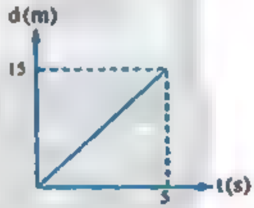
12 A car driver saw a child in the middle of the road at a distance of 25 m from his car which was moving with a speed of 12 m/s. He used the brakes after a response time of 0.5 s, so the car is decelerated at 6 m/s^2 till it stopped. Does the car hit the child or not ? Explain your answer.

13 The light year is the distance covered by light within a year on Earth in a speed of 2.98×10^8 m/s. How many meters in the light year ?
(where the year on Earth = 365.25 days)

(14) An object is projected horizontally from the top of a building and falls down at a distance d from the base of the building within a time t, if d = (50 ± 0.2) m and t = (10 ± 0.5) s, calculate the initial velocity by which the object is projected.

(15) A ball is projected vertically upwards from the surface of Earth and passed a person standing in a window at height of 28 m from the surface of Earth with a speed of 13 m/s.
Calculate :
(a) The initial velocity of the ball.
(b) The time required by the ball to reach the surface of Earth again.

(16) The opposite figure represents the (displacement - time) graph for a runner moving in a straight line with a uniform velocity. **Draw** the (displacement - time) graph for the runner if he moved with a uniform velocity of double his previous velocity in the same direction within the same period of time.



(17) An object moves according to the relation : $v_f = 10\,t$, calculate each of its initial velocity and acceleration.

Model Exam 8

First Multiple choice questions

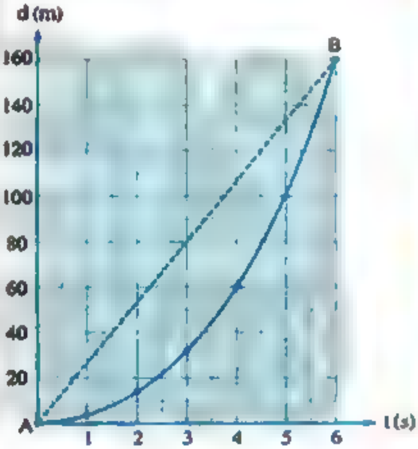
1 The time taken by a car that moves in a straight line with acceleration 2 m/s^2 so that its speed changes by 10 m/s is ....

ⓐ 0.5 s ⓑ 2 s ⓒ 5 s ⓓ 10 s

2 An object moved in a straight line a distance of 100 m with a velocity of 10 m/s, then it moved on the same line a distance of 200 m with a velocity of 5 m/s, so its average velocity through the whole trip equals ....

ⓐ 7.5 m/s ⓑ 6 m/s ⓒ 8 m/s ⓓ 30 m/s

3 The opposite figure represents the (displacement - time) graph for an object that moves in a straight line within 6 seconds, so the slope of the dashed straight line AB is ....



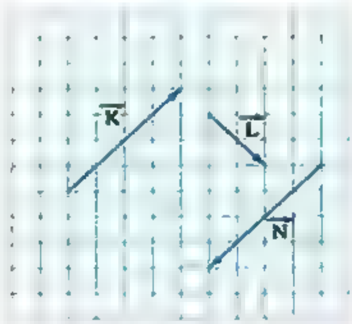
ⓐ greater than the average velocity of the object within 6 seconds.

ⓑ less than the average velocity of the object within 6 seconds.

ⓒ less than the instantaneous velocity of the object at the sixth second.

ⓓ equal to the instantaneous velocity of the object at the sixth second.

4 The opposite figure illustrates three vectors $\vec{K}$, $\vec{L}$ and $\vec{N}$, which of the following equations is incorrect ? ....



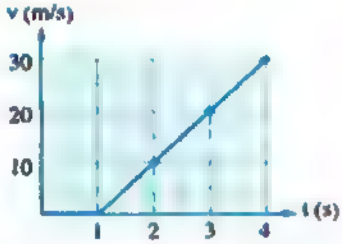
ⓐ $\vec{K} + \vec{N} = 0$

ⓑ $\vec{K} - \vec{N} = 2\vec{K}$

ⓒ $\vec{K} = \vec{N}$

ⓓ $\vec{K} + \vec{L} + \vec{N} = \vec{L}$

5 The opposite figure illustrates the (velocity - time) graph for an object, so its total displacement ....

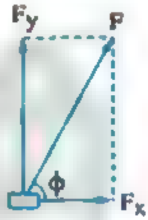


ⓐ 120 m
ⓑ 45 m
ⓒ 90 m
ⓓ 60 m

6 A car of mass 1000 kg moves with a uniform velocity of 12 m/s to the east, thus the resultant force acting on the car is ....

ⓐ 12000 N ⓑ 1200 N ⓒ 1012 N ⓓ 0

7 In the opposite figure if $F_y = 2F_x$, then the value of ϕ is ....



ⓐ 60°
ⓑ 37.67°
ⓒ 45°
ⓓ 63.43°

8 A racer claims that he can accelerate his car starting from rest to reach 180 km/h within 4 s, so he is expecting to cover 30 m from rest within a time of ....

ⓐ 12 s ⓑ 3.14 s ⓒ 2.19 s ⓓ 1.25 s

9 Two cars A and B are moving in a straight line where the speed of A increases from 12 m/s to 18 m/s within 3 s while the speed of B increases from 10 m/s to 25 m/s within 10 s. Which of the following statements is correct ? ....

ⓐ Displacement of A within 3 s < Displacement of B within 10 s
ⓑ Acceleration of B is double the acceleration of A
ⓒ Acceleration of A is double the acceleration of B
ⓓ Average velocity of A within 3 s > Average velocity of B within 10 s

10 The scalar product of the two vectors $\overrightarrow{A}$ and $\overrightarrow{B}$ equals 60 units and the magnitude of their vector product equals $20\sqrt{3}$ units, thus the confined angle between the two vectors equals ....

(a) 15° (b) 30° (c) 45° (d) 75°

Second Answer the following questions

11 An object is moving according to the relation $d = 2\,t^2$, calculate its speed after 5 s.

12 If the acceleration of an object equals zero, does this mean its speed equals zero ? Give example to your answer.

13 A tiger jumps horizontally from the top of a rock of a height 6.5 m above the surface of Earth with a speed of 3.5 m/s. Calculate the horizontal range of the tiger's motion. ($g = 10\ m/s^2$)

14 If $X = (5 \pm 0.1)$ cm and $Y = (7 \pm 0.2)$ cm, calculate $Y - X$.

15 If the maximum horizontal range for a projectile that is projected at an angle above the horizontal equals three times the maximum vertical height that can be reached by it, calculate the value of the projection angle.

16 If the force of viscosity (F) that acts on a ball of radius r which falls in a liquid of viscosity coefficient η is given by the relation $F = 6 \pi \eta r v$ where v is the uniform velocity of the ball, find the measuring unit of the viscosity coefficient η.

17 A box has fallen from a helicopter at a very large height from the Earth's surface during its rise vertically upwards with a uniform velocity of 8.76 m/s, calculate the distance between the box and the helicopter after a period of 3.05 s from the moment of its falling. ($g = 9.8\ m/s^2$)

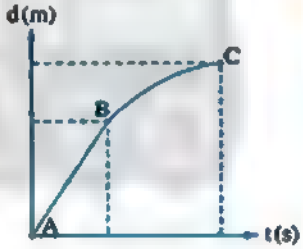
Model Exam 9

First Multiple choice questions

1. A ball of radius 1.7 cm, so its surface area equals ....
(knowing that : The surface area of the ball = $4 \pi r^2$)
ⓐ 2.1×10^{-5} m^2
ⓑ 9.1×10^{-4} m^2
ⓒ 3.6×10^{-3} m^2
ⓓ 0.11 m^2

2. Two balls A and B are projected vertically upwards from the same level such that the initial velocity of the ball A was double that of the ball B, so the maximum height reached by ball A is ....
ⓐ half the maximum height reached by ball B
ⓑ double the maximum height reached by ball B
ⓒ four times the maximum height reached by ball B
ⓓ eight times the maximum height reached by ball B

3. The opposite graph represents the relation between the displacement (d) and the time (t) for an object that moves in a straight line, which of the following statements is correct ? ....



ⓐ The object is at rest during the period BC
ⓑ The velocity of the object increases uniformly within the period AB
ⓒ The acceleration of the object within the period AB is positive
ⓓ The acceleration of the object within the period BC is negative

4. If A = (2 ± 0.01) m and B = (80 ± 2) cm, then the value of (A + B) equals ....
ⓐ (80.2 ± 2.01) m
ⓑ (82 ± 2.01) m
ⓒ (2.8 ± 2.01) m
ⓓ (2.8 ± 0.03) m

5 Two objects started motion from rest with a uniform acceleration in a straight line for a distance d, if the time of motion of the first body is three times that of the second, then the ratio between the acceleration of the first body to that of the second ($\frac{a_1}{a_2}$) is ....

ⓐ $\frac{1}{1}$ ⓑ $\frac{1}{3}$ ⓒ $\frac{1}{9}$ ⓓ $\frac{1}{81}$

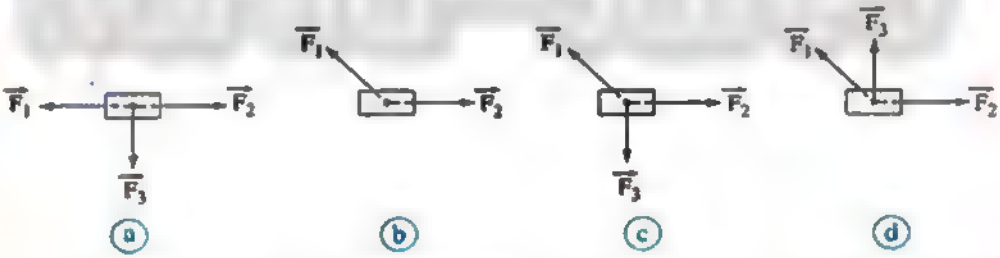
6 A ball is projected upwards with a velocity (v_i) in a direction that makes angle (θ) with the horizontal, when the ball reaches its maximum height, ...

ⓐ the resultant velocity of the ball equals zero and its acceleration equals zero
ⓑ the resultant velocity of the ball equals zero and its acceleration doesn't equal zero
ⓒ the resultant velocity of the ball doesn't equal zero and its acceleration equals zero
ⓓ the resultant velocity of the ball doesn't equal zero and its acceleration doesn't equal zero

7 If the dimensional formula for the two quantities x and y is $L T^{-1}$ and that for the quantity z is $L T^{-2}$, then the dimensional formula for the quantity k that verifies the equation : $x = y + zk$ is ....

ⓐ $L T$ ⓑ $L T^{-1}$ ⓒ L ⓓ T

8 The object that moves in a uniform velocity is represented by the figure ....



9 Two students are racing in a straight line, if the average velocity of the first student is 4 m/s and that of the second student is 5 m/s and the second student reached the end of the race before the first student by 5 seconds, then the distance of the race is ....

ⓐ 50 m ⓑ 75 m ⓒ 100 m ⓓ 150 m

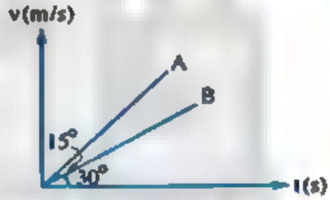
10 An object started its motion from rest with a uniform acceleration, if its velocity at the end of the fifth second was 5 m/s, then its average velocity when it covers 50 m equals ....

ⓐ 5 m/s ⓑ 10 m/s ⓒ 15 m/s ⓓ 20 m/s

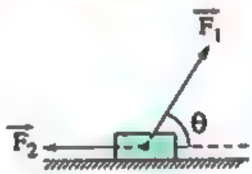
Second Answer the following questions

11 When the speed and time of motion of a car are measured they are found to be (25 ± 0.5) m/s and (1 ± 0.01) s respectively, calculate the distance covered by the car during this period.

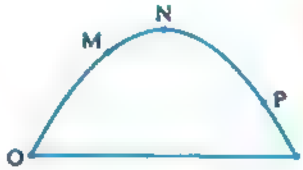
12 The opposite figure illustrates the relation between the velocity (v) and time (t) for two objects A and B that started their motion from rest, calculate the ratio between the acceleration of the two objects A and B respectively.



13 The opposite figure illustrates a box that moves horizontally with a uniform velocity on a frictionless surface under the effect of two forces, if we decreased the magnitude of the force F_2 while F_1 is kept constant, what will be the change in the angle θ that keeps the box moving in the same velocity ?



14 A player projects a ball upwards from the Earth's surface at an angle to the horizontal and the opposite figure illustrates the path of the ball, arrange the points N, M and P according to the speed of the ball in each point starting from the higher velocity ignoring the resistance of the air.



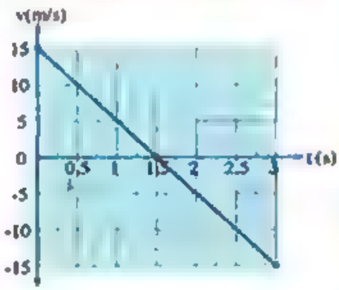
15 In the opposite figure if the resultant vector for the two vectors $\overrightarrow{A}$ and $\overrightarrow{B}$ is perpendicular to vector $\overrightarrow{B}$, calculate the value of vector $\overrightarrow{A}$.

16 The speed of a train is decreased in a uniform rate from 96 km/h to 48 km/h through a distance of 800 m due to using the brakes, calculate the distance covered by the train from the moment of using the brakes till it stops if it was moving with the same acceleration.

17 The opposite graph illustrates the relation between the speed of an object that is projected vertically upwards from the surface of Earth and the time, from the figure find :

(a) The speed of the object at the moment it touches the ground.

(b) The displacement of the object.



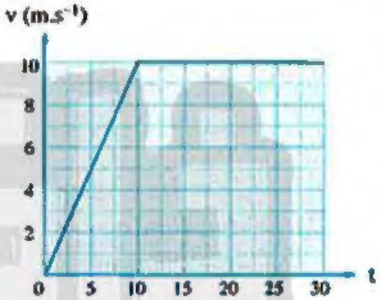
Model Exam 10

First Multiple choice questions

1. Two similar balls fell freely from the top of a sky scraper such that the second ball fell 1 second later after the first ball, if we ignored the resistance of the air and observed the falling of the two balls in the Earth's gravitational field, then the distance between the balls during falling ....

(a) remains constant
(b) increases
(c) decreases
(d) equals zero

2. The opposite graph represents the change in the speed of a girl that runs in a straight race track with the time. If the girl covered a distance of 200 m within 25 s , which of the following choices is correct at the time of 25 s ? ....



	The instantaneous velocity	The average velocity
(a)	8 $m.s^{-1}$	8 $m.s^{-1}$
(b)	8 $m.s^{-1}$	10 $m.s^{-1}$
(c)	10 $m.s^{-1}$	8 $m.s^{-1}$
(d)	10 $m.s^{-1}$	10 $m.s^{-1}$

3. If an object moved along the circumference of a circle such that its displacement after half cycle becomes 2π m , then the value of the covered distance is ....

(a) π m
(b) $\frac{\pi}{2}$ m
(c) π^2 m
(d) 2π m

4 The statement that does not express the action and the reaction forces is ....

(a) The magnitude of the action force equals the magnitude of the reaction force
(b) The action force is opposite to the reaction force in direction
(c) The action and the reaction forces act on the same object
(d) The action and the reaction forces have the same nature

5 NASA space agency is connecting with the astronauts through radio waves. If the time taken between the transmission from Earth and receiving on the Moon is 1.28 s and the speed of radio waves is 3×10^8 m/s , then the distance between the Earth and the Moon is ....

(a) 240×10^3 km
(b) 384×10^3 km
(c) 480×10^3 km
(d) 768×10^3 km

6 When a body starts its motion from rest in a straight line with an acceleration of 10 m/s^2, this means that ....

(a) slope of the (v - t) graph of the body equals 5
(b) slope of the (d - t^2) graph of the body equals 10
(c) slope of the (v - d) graph of the body equals 10
(d) slope of the (v^2 - d) graph of the body equals 20

7 If x = 250 ms , y = 1500 μs , then the value of (x + y) equals ....

(a) 0.2515 s
(b) 4 s
(c) 250.15 s
(d) 1750 s

8 A car is moving on a horizontal road with a uniform velocity of 10 m/s and is affected by a frictional forces of 1500 N , so the force by which the engine acts on the car is ....

(a) 150 N
(b) 1500 N
(c) 15000 N
(d) 0

9 An object is moving with a uniform acceleration according to the relation : $\frac{2\sqrt{d}}{3}$
So, its speed after 2 s since it started its motion is ....

(a) $\frac{4}{9}$ m/s
(b) $\frac{2}{3}$ m/s
(c) 4 m/s
(d) 9 m/s

10. A car moves in a straight line with a uniform acceleration where its velocity changed from 10 m/s to 90 km/h within 20 s , so the acceleration of the car and its type are ....

(a) $0.75\ m/s^2$, positive acceleration
(b) $4\ m/s^2$, positive acceleration
(c) $0.75\ m/s^2$, negative acceleration
(d) $4\ m/s^2$, negative acceleration

Second Answer the following questions

11. Explain the decrease in the speed of an object that is projected vertically upwards till it vanishes.

12. A vector $\vec{v}$ of 16 units makes an angle 50° with the x-axis, calculate the vertical and the horizontal components for this vector.

13. What happens if a body is projected at an angle 75° to the horizontal, then it is projected once more with the same initial velocity at an angle 15° to the horizontal (concerning the horizontal range) ?

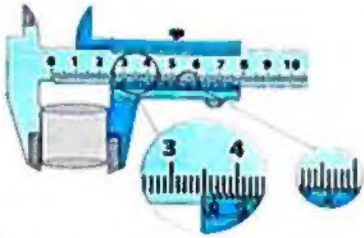
14. The opposite figure illustrates the path of a stone that is projected vertically upwards to pass by three similar windows that are at equal distances from each other, arrange these windows in a descending order according to the change in the speed of the stone (Δv) during its passing in front of each of them.

15 The opposite figure illustrates a vernier caliper used to measure the radius of a metallic cylinder.

From the figure find :

(a) The measured value for the thickness of the cylinder.

(b) The relative error for that measurement if the actual value of the radius of the cylinder is 3.68 cm.



16 In a basket ball match, a player threw the ball as in the opposite figure, calculate :

(a) The speed by which the player should throw the ball to reach the target basket.

(b) The maximum height reached by the ball from the projection plane. ($g = 10\ m/s^2$)

17 A car spent three hours during its trip in a straight line. If its speed during the first hour was 90 km/h and during the last two hours was v and its average velocity during the whole trip was 75 km/h, calculate the value of v.